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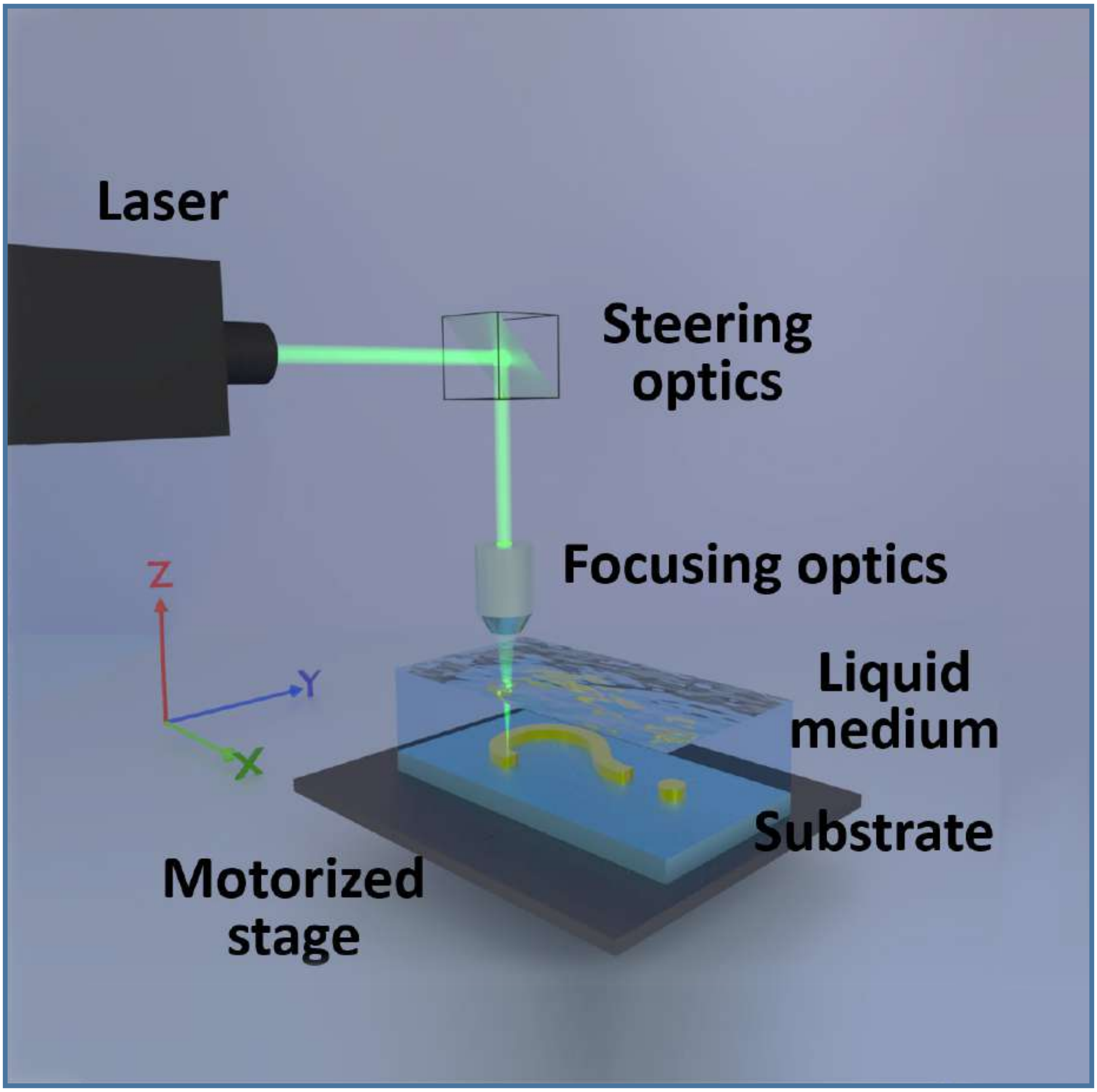

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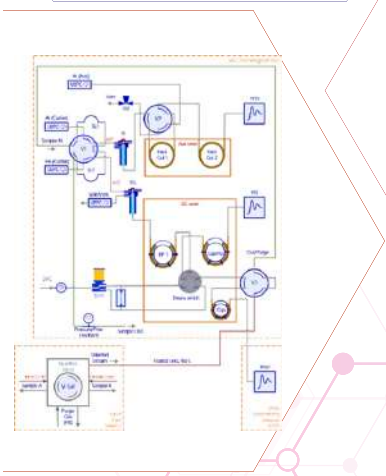

1 GC ו- GC/MS

במגוון קונפיגורציות, עם כל מגוון הגלאים הקיימים בשוק.

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- אנלייזרים ייחודיים בהתאם לשיטות המפותחות אצל היצרן, ועוברות ולידציה.
- אנלייזרים המפותחים על פי דרישות ספציפיות ואפליקציות של הלקוח לאנליזות רוטיניות.

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הן בהנדסת החומרה (להתאמה לדרישות הלקוח) והן בהנדסת התוכנה (לשליטה, בקרה, דיאגנוסטיקה, עיבוד תוצאות, דוחו"ת ועוד).

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Editorials

Scientific Articles

History of Chemistry Article

Profile

Reports

Dear Readers,

Welcome to the eighth issue of the Israel Chemist and Engineer (ICE) online magazine, a publication of the Israel Chemical Society (ICS). We hope you will find the magazine interesting and will be inspired to contribute to future issues.

We have two scientific articles on novel topics, one by Hagay Shpaisman of Bar-Ilan entitled “Laser-guided printing” and one by Charlotte Vogt of the Technion entitled “Separating the ‘players’ from the ‘spectators’ in operando spectroscopy of catalysis”. Bob Weintraub continues to inform us about the history of science, this time with an article entitled “Sidney Loeb and the origins of pressure retarded osmosis”. Rachel Mamlok-Naaman of the Weizmann Institute, the recipient of the 2020 IUPAC award for distinguished women in chemistry or chemical engineering, has contributed an article on “Women in science”.

I had the pleasure of interviewing Avi Domb of the Hebrew University for this issue of the ICE. Avi is currently serving as the Chief Scientist of the Israel Ministry of Innovation, Science and Technology, yet another peak in his colorful and varied career.

Finally, the indomitable ICS President Ehud Keinan presents a report of the 2021 ICS prize ceremony that was held in July 2021 at the Open University campus in Ra’anana in lieu of the 2021 ICS annual meeting that had to be cancelled due to the covid-19 epidemic.

If you have suggestions for future editions, comments on the current issue, or would like to contribute an article, please contact me at gordon@biu.ac.il.

Arlene D. Wilson-Gordon

Professor Emerita

Chemistry Department, Bar-Ilan University

ICE Editor

Dear Colleagues,

Although the Covid-19 pandemic with its consequences will continue affecting every aspect of our life, it seems that we have crossed the worst phase, and have gradually resumed all the professional and personal activities of pre-Covid times. We had to skip the 2021 Meeting, but we kept our traditional award ceremony and held it at the Open University campus on July 1, 2021 (see my report in this issue). The 86th ICS Annual Meeting, initially scheduled for February 2021, will take place on February 22-23, 2022. I expect high attendance because many ICS members and students are eager to meet physically rather than virtually, resume beneficial networking, and exchange their ideas and recent discoveries. Profs. Charles Diesendruck and Saar Rahav of the Technion's Schulich Faculty of Chemistry will chair the meeting. I look forward to seeing many of you at this gathering.

The establishment of the ACS Chapter in Israel marks a significant advance for our Society. On November 18, 2021, we celebrated the Chapter's inauguration at the Open University campus in Ra'anana. Many ACS members attended the event with their spouses. They participated in an informal discussion on the Chapter's goals and plans, such as ICS–ACS joint membership, research funding opportunities, ACS–ICS joint symposia at the ACS National Meetings, binational collaboration, and exchange programs of scientists, graduate students, and even high-school pupils. We also discussed the preparations for the elections of the Chapter's officers - President, Secretary-General, and Treasurer. In my introductory comments, I explained that the ACS is the largest and most influential chemical society worldwide. Founded in 1876 (just 57 years before the establishment of the ICS), the ACS has become a truly international organization with 20% of its 155,000 members residing outside the USA. The 25 international chapters add to a remarkable array of 33 technical divisions and 186 local sections. At the end of the evening, Prof. Dan Shechtman of the Technion, who received the 1999 Wolf Prize in Physics, and the 2011 Nobel Prize in Chemistry for discovering quasiperiodic crystals, lectured on "American and Israeli Wolf Prize Laureates, and their scientific achievements."

As you may know, the International Union of Pure and Applied Chemistry (IUPAC) has recently elected me to become the Union's 41st President. It is the second time in the 103-year history of IUPAC that the Union has an Israeli President. The first was Prof. Joshua Jortner, who served as the 28th President (1998-1999). I feel honored to continue his legacy.

My service as Editor-in-Chief of the Israel Journal of Chemistry (IJC), the ICS's Official Journal, continues to be a source of great satisfaction. The newly released Impact Factor (IF) for 2020-2021 is 3.333, representing a 43.7% increase from last year. Even more impressive is the IJC Total Citations of 3520, representing a 28.40% increase from last year. It is remarkable that within just one decade since we started our collaboration with Wiley-VCH, the IF increased from 0.380 to 3.333, and citations went up from 883 to 3520. The credit for these achievements goes to many of you who served as Guest Editors of topical issues or contributed highly cited articles. Please get in touch with me directly for any new ideas concerning future topics that deserve to be highlighted by our journal.

Finally, I am delighted to see this ICE magazine developing under Editor-in-Chief, Prof. Arlene Wilson-Gordon. I encourage you to contribute an article to the ICE on any topic you like, including popular science, history of science, report on an event, opinions, etc. Please, don't hesitate to contact Arlene or me on these matters.

Enjoy your reading,

Ehud Keinan

President, the Israel Chemical Society

Laser-guided printing

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Ehud Greenberg,[a,b] Nina Armon,[a,b] Eitan Edri,[a,b] Ornit Nagler-Avramovitz,[a,b] Yuval Elias[a] and Hagay Shpaisman[a,b*]

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Abstract:

Laser-guided assembly of microstructures where materials are patterned into 2D/3D structures with (sub) micron resolution and less waste than standard top-down methods has many applications including microelectronics, sensors, and medical devices. Liquids allow a simple setup and may be easily handled and recycled. However, this simplicity conceals various underlying mechanisms that cannot be identified by simply observing the initial or final materials. Furthermore, this field is of interest to chemists, physicists, and chemical/material engineers where each group is focused on different aspects of the deposition process, sometimes leading to confusion regarding the overall mechanism. Here we offer a methodical short overview where mechanisms are divided according to the material source – preformed or locally synthesized, and then by the driving force. Various methods are compared, and advantages and limitations are discussed. Finally, we illuminate various future directions for advancing this exciting field.

1. Introduction

Formation of patterns is important for many applications including medicine, robotics, electronics, and food production. Structures produced by bottom-up approaches, in two dimensions as well as in three-dimensional additive manufacturing (AM), may be more complex and incur less waste than traditional methods. The microscale is particularly important for electronic, optoelectronic, photonic, electromechanical and medical devices, as well as for various sensors. Moreover, personalized macro-scaled products such as implants and drugs often have micro-sized features, which play an important role. Highly precise optical manipulation of light offers outstanding resolution, while printing at high speeds is achieved by rapid steering of the laser. A large variety of materials including metals, oxides, alloys, polymers, and biological cells have been assembled by laser-based methods. Techniques based on liquids are desirable as they allow simple setups, easy handling, excellent resolution, and recycling with minimum waste.

Focusing on assembly based on lasers in liquid environments, the common setup (Figure 1) encompasses several mechanisms. Variants combine different principles of operation. Different mechanisms, operation modes and material characteristics are therefore easy to miss. Whereas reviews on printing with lasers deal primarily with preformed materials, local synthesis is mentioned mainly in reviews that survey a wide range of methods, such as those composed by Elder [1] and Ngo [2] and coworkers. Specific material families have also been reviewed, e.g. metal microstructures by Hirt and coworkers [3]. Here, we offer a short overview that presents both preformed material deposition and *in situ* synthesis. We refer the interested readers to our recent in-depth progress report [4]. Methods are divided by the driving

Upper left, clockwise: Ehud Greenberg, Dr. Nina Armon, Dr. Eitan Edri and Ornit Nagler-Avramovitz are PhD students (Nina and Eitan have graduated) in the lab of Prof. Shpaisman. Dr. Yuval Elias is the scientific editor of the Chemistry Department at Bar-Ilan University.

Hagay Shpaisman is an associate professor at Bar-Ilan University and leads the laboratory of directed material assembly, devising and developing new methods for bottom-up assembly.

force leading to material deposition, and mechanisms are explained. Table 1 briefly summarizes various methods in terms of the mechanism and key aspects.

Table 1. Brief comparison of printing methods. Adapted with permission [4]. Copyright 2021, Wiley-VCH.

Printing method	Mechanism	Materials	Maximum speed	Feature size	Comments
Photo-thermal	Local heating by laser – temperature gradient: I) ion separation – local electric field, supports movement of charged particles towards heated area and/or II) particles carried by liquid (bulk) motion towards focal point.	Metals, polymers, organic molecules	~1 μm/s	300 nm – 200 μm	Reconfigurable printing was demonstrated.
Micro-bubble assisted	Local heating increases the vapor pressure until a micro-bubble is formed. Convective flows, capillary forces carry particles towards base of micro-bubble where some are pinned.	Metals, polymers, organic molecules	10 mm/s	~510 nm – 50 μm	I) Laser modulation forms continuous patterns. II) 3D particle-covered hollow spherical structures were shown.
Optical forces	Optical forces due to photon momentum conservation (particle >> λ) or electrostatics (size << λ) used to either: I) optically trap and deposit materials at desired locations on the substrate, or II) push toward the substrate (scattering force).	Metals, polymers, organic molecules, living cells	particle every 5 s	Individual objects (mostly) deposited selectively nanometers to micrometers	I) Minimal inter-particle distance – 60-150 nm. II) Fixation by gel and electrophoresis.
Single photon reactions	Polymerization by photons with enough energy to excite electron from ground to higher state close to liquid surface (poor selectivity in *z*-direction). Layered approach forms 3D polymeric microstructures.	Photocurable resins	4000 mm/s	5–70 μm	Available commercially.
Multi photon reactions	Non-linear process – at least two photons required to excite electron, promoting chemical reaction. High energy pulsed lasers polymerize/reduce metal ions. Laser energy tuned to produce sub-diffraction-limit features. 3D microstructures by multi-photon reactions (freely moving focal point).	Photocurable resins, metals	0.9 mm/s	65 nm – 5 μm	Commercially available.
Thermally driven reactions	Occur upon heating due to laser light absorption, increasing probability to overcome activation barrier and promote electron transfer.	Oxides, metals, polymers, organic molecules, alloys, compounds (molecular)	10 mm/s	~0.7–500 μm	Multi layered (2.5D)[5] and simple 3D microstructures were demonstrated.

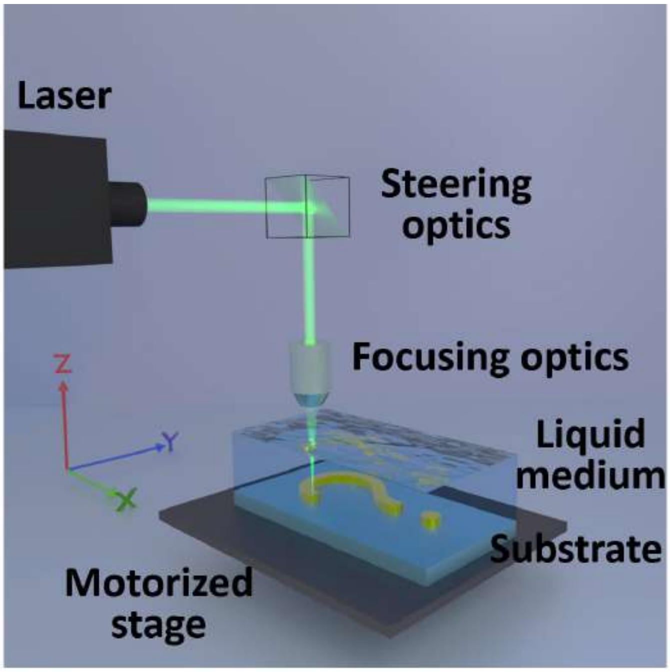

Figure 1. Common setup for laser guided printing from a liquid medium. Laser focused on the liquid forms 2D/3D microstructures by moving relative to a substrate carrying liquid. The various deposition mechanisms are represented by a question mark. Reproduced with permission [4] . Copyright 2021, Wiley-VCH.

2. Directed assembly of preformed materials

Focused laser illumination can assemble preformed materials at the focal spot owing to thermal and/or optical force.

2.1. Thermal force

Photo-thermal heating moves particles mainly by thermophoretic motion and convective flow. Micro-bubble assisted printing is a special case where the motion is convective, and particles are pinned to the microbubble base.

2.1.1. Photo-thermal printing

Thermophoresis — particle motion due to a thermal gradient — proceeds mainly by an opto-thermoelectric mechanism. Local heating leads to a temperature gradient and ion separation according to the Soret coefficient. The consequential local electric field results in movement of charged particles towards (or away from) the heated area (Figure 2a, right).

Photo-thermal printing may alternatively proceed by a mechanism in which the liquid motion carries particles. Local heating of the liquid can produce variations in pressure, density and surface tension. The density tends to decrease with temperature, as most solvents expand, resulting in flow driven by buoyancy, gradients in pressure, and local

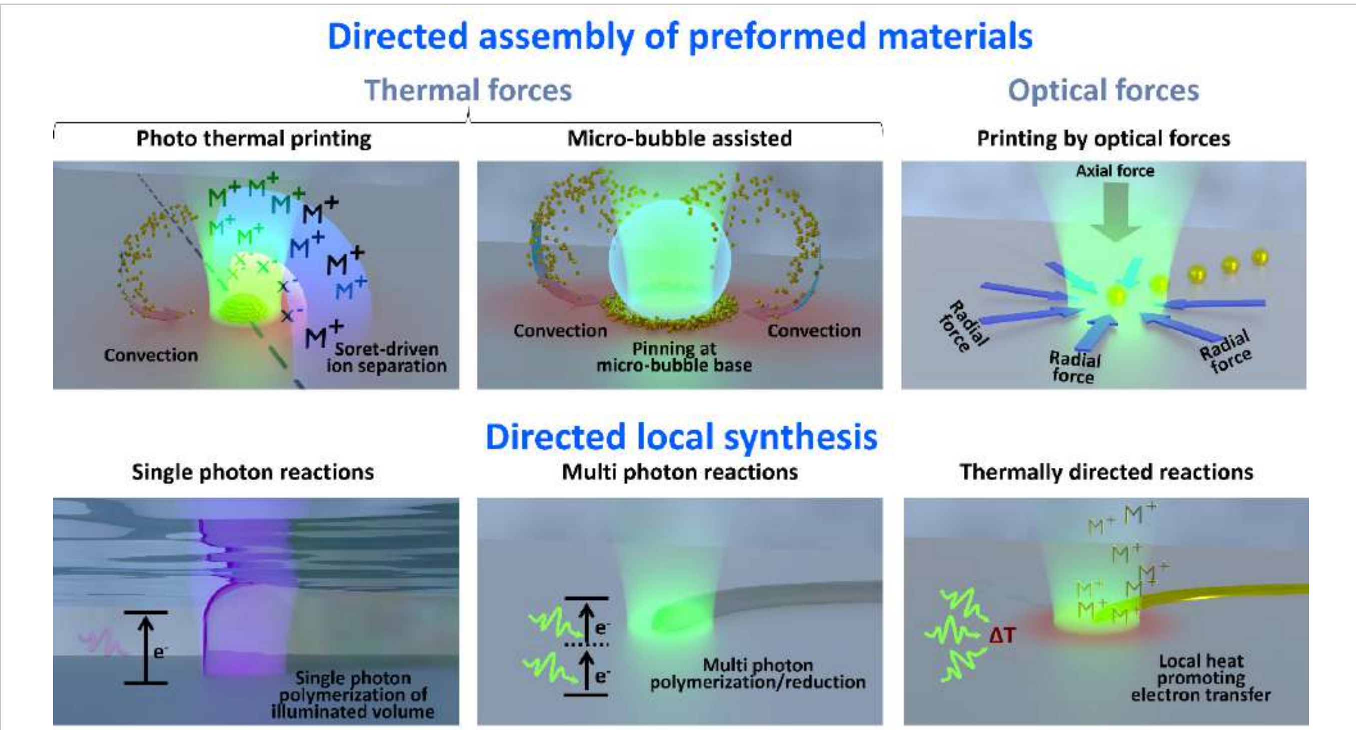

Figure 2. Methods of printing from a liquid according to material origin – preformed/synthesized locally. Preformed assembly methods are divided according to forces that affect material movement towards the focal spot. Local synthesis methods are divided according to the photon absorption mechanism. Reproduced with permission [4]. Copyright 2021, Wiley-VCH.

convection. With heat, the surface tension becomes lower, and the flow proceeds according to Marangoni convection. Drag forces act on the particles, which move along streamlines of the liquid (Figure 2a, left).

While material accumulation following heating by opto-thermal means has been shown quite commonly, few researchers demonstrated assembly on substrates in a permanent manner. Such permanent fixing of dispersed materials may be achieved by making the continuous phase solid (e.g., hydrogel) by depletion forces or Van der Waals interactions.

2.1.2. Micro-bubble assisted printing

A beam produced by a continuous wave (CW) laser is absorbed by the particles or by a substrate that absorbs light. Due to the resultant heating, the pressure of the vapor increases until a microbubble is formed [6]. Focusing the laser close to the interface of the liquid and the substrate produces a gradient in temperature, such that the part of the microbubble closer to the substrate is hotter. This produces gradients in surface tension and density, which lead to convection currents (natural and Marangoni, respectively) that carry the particles, along with capillary forces. Some of the particles are pinned at the interface between the three phases (gas, liquid and solid) and show typical spherical deposition around the contact area of the bubble/substrate (Figure 2b) [7,8].

By moving the sample or the laser, the micro-bubble can propagate by depinning the bubble/liquid/substrate interface. Particles are deposited around the new location of the bubble, and micro-structures can be printed by repeating this process. Continuous patterns may be formed by laser modulations that enable improved control over the microbubble's size and prevent its pinning to the deposited material [7].

2.2. Optical forces

Optical tweezers (OTs) are the best known method that uses optical forces to manipulate particles [9–14]. When the particle size is considerably greater than the wavelength of the laser (Mie regime), a force is generated in accordance with momentum conservation of absorbed, reflected or refracted photons. If the refractive index is higher than that of the medium, the force will pull/push it towards the most intense gradient. Nanoparticles (NPs) much smaller than the wavelength (Rayleigh regime) experience an electrostatic force due to different polarizability with respect to the medium. NPs with higher polarizability have a dipole moment that arises from the light's electric field, and advance along the intensity gradients toward the focal point. Axial/radial components are parallel/perpendicular to the beam direction. Materials trapped with OTs may be micro-printed on substrates (Figure 2c) by movement of the trap with respect to the substrate. Interestingly, optical forces allow micro-printing even without optical trapping. Material can be pushed towards the substrate using the component along the axis (e.g., for particles that are highly scattering). In either case (trapping/pushing), Van der Waals interactions can bind particles with the substrate. Particles may be permanently set on the substrate also by local thermal heating, gelation, electrophoretic deposition, and ultraviolet (UV) triggering.

3. Local directed synthesis

Beyond particle/cell assembly, lasers allow localized synthesis from liquid/dissolved precursors. Advantages include greater stability and avoidance of preparation steps or stabilizers that can have a negative impact on the properties of the deposited material. Complex systems can be formed more easily, for example alloys, which are difficult to produce from materials that are preformed.

3.1. Single-photon reactions

When a single photon excites an electron, thereby promoting a chemical reaction, photo-polymerization may occur in which laser irradiation polymerizes liquid or dissolved monomers. For liquids, reactions of single photons arise from laser illumination (mainly in the UV range) where photons can excite electrons (Figure 2d). The resin includes liquid molecules with a variety of functions – building blocks (monomers/cross linkers) and photo-sensitizers, which absorb light and transfer energy to photo-initiators, forming reactive species (e.g., radicals/cations) that initiate polymerization. These functions can be obtained in molecules of different type, or in separate parts of molecules of the same type. The desired 2D micro-structure is formed by steering the laser on a (thin) layer of the resin. Repeated scanning with an additional thin layer produces a 3D polymeric microstructure. The need for such layered 3D printing arises from the limited depth of penetration and selectivity in the perpendicular direction (along the z-axis). This technology is used commercially in many systems for a variety of applications.

3.2. Multi-photon reactions

Non-linear multi-photon processes where electron excitation requires more than one photon (and a chemical reaction is promoted) proceed with rather low probability, as nearly simultaneous absorption is needed to initiate the process, requiring high energy pulsed lasers. The multi-photon absorption mechanism is used mainly for photo-polymerization and reduction of metal ions. Usually, the liquid is transparent to the wavelength, obviating the need to add layers of thin liquid resin for 3D formation (required for single photon reactions). The substrate is moved relative to the focal point, and 2D/3D structures are produced inside the liquid resin bulk (Figure 2e). In this non-linear process with threshold effect, the laser energy can be tuned to produce sub-diffraction-limit features.

Multi-photon and single photon polymerizations require similar components (see Section 3.1): building blocks and photo-sensitizers/initiators. Multi-photon reduction requires electron acceptors (metal ions) and photo-reducing agents. The reduction process was suggested to form NPs and structures of metal by nucleation, growth, and aggregation. Commercial units are available for high-resolution polymeric 3D printing (e.g., by Nanoscribe and Microlight3D) and are used for various applications.

3.3. Thermally driven reactions

When heat is generated by absorption of the laser, there is a greater probability that the reaction activation barrier will be overcome and electron transfer promoted (Figure 2f). It was suggested by Lachish-Zalait et al. [16] that initiation of the deposition process requires adsorption to the substrate of very small amounts of precipitate, which absorb laser radiation and undergo thermal decomposition. Metals as well as oxidized metals are produced from precursor solutions that consist mostly of metal ions, which have an activation energy that is higher than that of the photons. The reaction is sometimes faster than expected due to the local rise in temperature, explained by the gradient in temperature between the spot of the laser and the medium; the resultant convection flows provide a steady supply of precursors. Minimal diameters of microstructures (circular deposition) and linewidths are ~0.7–500 μm.

Recent studies suggested a major role for microbubbles [17,18] attributed to gradients that lead (see Section 2.1.2) to convection currents; in combination with capillary flow and liquid evaporation around the microbubble. These currents were thought to increase ion concentration and even lead to supersaturation. Due to the higher temperatures and concentrations, material is deposited around the three-phase (liquid/gas/solid) contact interface. Greenberg et al. [17] showed deposition at the interface of NPs that were formed in liquid (along with materials that were synthesized locally). Laser modulation prevents pinning of the bubble to the deposited material and improves control over its size.

4. Discussion

Due to the similarity between the various methods, the differences in underlying mechanism, operation, and characteristics of the printed material can easily be missed. There is no "perfect" method. Figure 3 reveals that certain applications require a specific method. For example optical forces, while inferior in terms of speed, are the only method that allows particles to be placed in close proximity (60 nm apart) and living cells to be manipulated. Reactions of single photons offer the greatest speed but are limited to printing of polymers.

Methods that enable microfabrication of various materials are advantageous, as flexibility in material choice allows better compatibility for diverse applications. Some methods demonstrated deposition of various materials. Directed assembly of preformed metals, polymers and organic materials can be expanded to deposit NP dispersions of other materials. Another advantage of such deposition is exceptional control over size and shape of particles forming the microstructure, as specific properties can be chosen. Local synthesis is obviously not applicable to living cells.

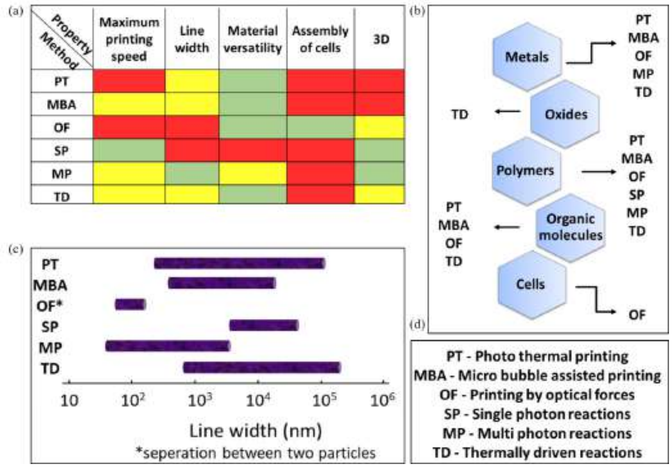

Figure 3. (a) Various aspects of laser-based printing from liquids – green (excellent), yellow (mediocre), red (poor). (b) Printing methods applicable for various material families and (c) linewidths. (d) Abbreviations. Reproduced with permission [4]. Copyright 2021, Wiley-VCH.

Various applications benefit from minimal feature size. Photo-thermal, micro-bubble assisted, multi photon and thermally driven printing all achieve sub-micron feature size, while single-photon reactions are limited to microns. While diffraction is considered a limiting barrier, features with a smaller size of tens of nm were achieved by reactions with multiple photons due to non-linear processes. The size range provided by one laser passage is significant for applications that require a feature size much larger than the minimal value. Repeated printing with a small feature size not only requires significant time but may also provide subpar quality due to boundaries between adjacent features. Diverse feature size is also required for connection of macro-sized objects to micro and sub-microstructures.

5. Conclusion & outlook

Laser-based printing from liquids appear promising for various applications. It is simple, uses materials that allow easy handling and efficient recycling, and allows versatility, high resolution, and printing of arbitrary structures on various substrates. Traditional methods for fabrication such as inkjet printing, selective laser sintering (SLS) and lithography may be combined with laser-based methods.

Laser-guided printing offers a number of advantages, and may complement or replace top-down approaches. Printing of micro-structures with single/multi-photon polymerization is highly developed and commercially mature. However, it is limited to polymers; for other materials, appropriate methods are needed. Commercialization requires scaling up, e.g. printing in parallel with separate beams, or increasing velocity. Limits of printing velocity and feature size should be studied theoretically and experimentally. Methods currently limited to 2D assemblies require additional research to allow 3D microstructures. Micro-sized structures are envisioned not only within macro-sized objects, but also as standalone objects, e.g. for medical usage. For such micro-objects (e.g., devices and robots) materials need to be assembled with different functionalities. Microprinting of materials with "smart" properties (e.g. shape-memory polymers) and tailored composites are essential. By comparing the various mechanisms, this overview will hopefully illuminate the different methods and lead to future developments.

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Separating the "players" from the "spectators" in operando spectroscopy of catalysis

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Abstract

Surface processes at complex material interfaces are important for many different applications, most notably heterogeneous catalysis. Approximately 90% of chemical processes - and thus nearly all manmade things - include at least one catalytic step. Studying relevant surface processes allows us to rationally design new or better catalysts and materials but it is difficult to do so under relevant conditions of temperature, pressure, and material complexity. In this article, I discuss an experimental approach borrowed from lock-in amplifiers, equipment often found in physics laboratories, which can overcome many of these challenges. In this way, we can study details of catalytic reactions under highly relevant conditions with the aim to generate the next generation of fundamental insights into surface processes.

1. Studying catalysts at work

1.1 The complexity of catalyst systems

A surface or an interface defines a boundary between a material and its surrounding environment. At an atomic level, surface atoms have a different chemical environment from those in the bulk of the material; they have fewer nearest neighbors. As such, surface atoms exhibit higher chemical reactivity, and this general property makes them very useful in a large variety of chemical and biological processes. To increase the available surface per unit weight of material, it is common practice to finely divide the material whose surface properties are desired, thereby forming e.g., nanoparticles which are often supported on high-surface area (metal oxide) supports. Another commonly used form of (high-surface area) catalysts are zeolites, which act as solid Brønsted acids. Supported nanoparticular catalysts and zeolites by far make up the largest fraction (in terms of catalyst weight, product weight, and also economic value) of processes that are applied industrially. Such materials are used and studied throughout industry and academia, for example in catalysis, but also in materials science, across energy storage applications, and so forth, due to their high chemical reactivity and stability [1].

During catalytic processes, molecular adsorbates at the surface affect the surface, geometric, and electronic structure of the catalysts, particularly so at the high temperatures and pressures which are often relevant to actual applications (for example, the Haber-Bosch process occurs above 350 °C and at pressures of over 200-300 bar) [2]. Our current understanding of such fundamental changes to relevant catalysts at operating temperatures and pressures is lacking; there are so-called temperature-, pressure- and material complexity gaps [3]. One of the reasons that so much is still unknown is that it is inherently difficult to study processes at surfaces under relevant conditions. For a catalytic system that is in interaction

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with adsorbates, depending on the mode of operation, spectroscopic signals are generally of low relative intensity. This holds true both for surface-sensitive spectroscopies, and bulk techniques. Figure 1 shows some applications and limitations of commonly applied spectroscopic techniques, X-ray absorption spectroscopy (XAS) and infrared (IR) spectroscopy, to study catalytic reactions. Firstly so, they are limited because the exposed surface-fractions of the metals that comprise nanoparticles are often in the single-digit percentile, as is the fraction of Brønsted acid sites of a zeolite. For example, an 8 nm Ni nanoparticle consists of approximately 25,000 atoms [4], of which approximately 0.1 are surface atoms. Secondly, spectral information is often heavily clouded by the least active species [5] as different types of sites, or surface fractions, have different interactions with adsorbates. Furthermore, of the relatively small fraction of exposed surface, an even smaller fraction does the actual job [6]. In practice, this means that the majority of the signals in a spectroscopic measurement come from the molecules that are the most stable (i.e., the least reactive), instead of the molecules that are undergoing reaction or, in other words, "spectator species" mask active species. Thirdly, surfaces and in particular nanoparticles are structurally highly dynamic under the elevated temperatures and pressures at which they are often applied, and particularly when exposed to adsorbates or reactants [7].

To summarize, our fundamental knowledge of the interaction of adsorbates with nanoparticles is lacking due to:

1. Small spectroscopic signal changes in noisy environments
2. Broad and convoluted signals
3. Adsorbate-surface systems change dynamically, particularly so as a result of the processes under study.

1.2 Past and present approaches

For these reasons, an overwhelming majority of studies in the literature have oversimplified the systems under study, for example, by using single crystal facets, studied under ultra-high vacuum conditions (an approach that is termed surface science) [3, 7-11]. These approaches have yielded many of the important insights on which we currently build our understanding. However, in recent years it has become increasingly apparent that adsorbates and surfaces have completely different physical parameters, such as surface stability, mobility of species, surface coverages, and surface energies, at relevant conditions of pressure and temperature [3, 12, 13].

Several surface-science groups around the world are attempting to close this gap by performing surface-science experiments at less high-vacuum conditions, approaching "ambient" pressures [13–15]. However, many of these approaches still make use of model surfaces rather than the supported nanoparticles that are used in applications, and these measurements are generally performed in a static manner. When a static measurement is performed on a surface that is in chemical and physical equilibrium, much information is lost as to how this equilibrium was reached. That is, for a given reaction intermediate to cover a surface, often several sequential elementary reaction steps have occurred on the time scale of milliseconds to seconds, each of which affect the surface and subsequent steps [1, 16]. Notable approaches to study model surfaces at conditions more relevant to applications are, for example, high-pressure scanning tunneling microscopy (STM) of model hydrodesulfurization catalysts working together with an industrial partner [17, 18]. The same group is working on integrating STM and

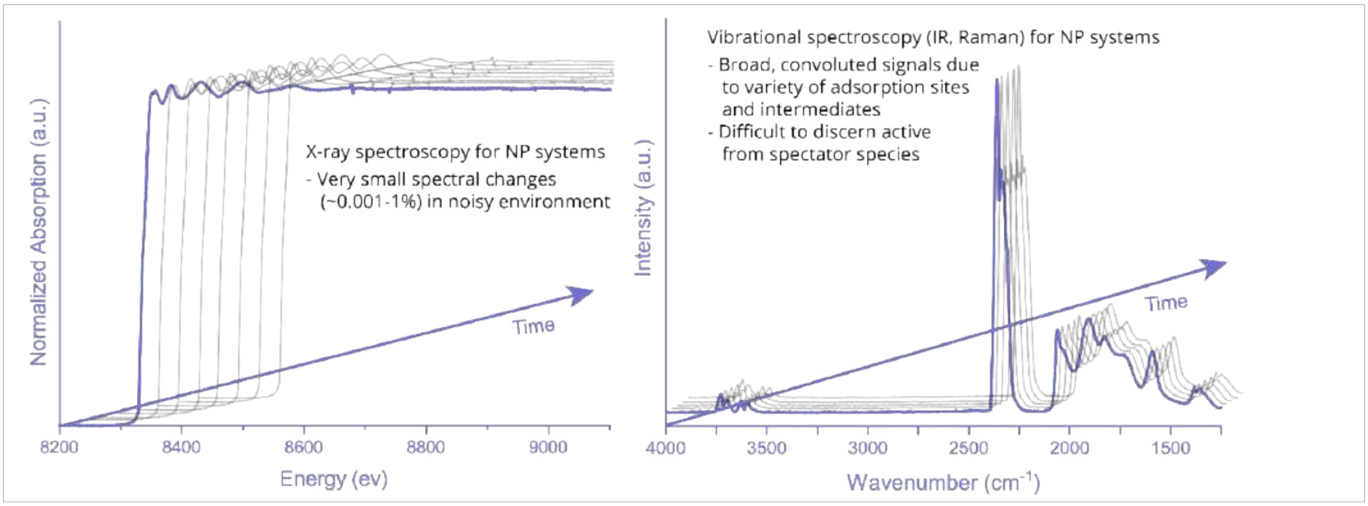

Figure 1. Two ensemble (bulk) spectroscopy types (X-ray absorption spectroscopy, and infrared absorption spectroscopy) which can be applied at high pressures and temperatures, and at high temporal resolution and their limitations in the field of study.

atomic force microscopy (AFM) in a single microscope, applicable at high pressures. Furthermore, static micro-spectroscopy measurements have been performed in gaseous environments with spatial resolutions of down to 20–30 nm [19]. Notable efforts from catalysis company Haldor Topsøe include a focus on advancing high-resolution transmission electron microscopy (HR-TEM) for heterogeneous catalysis applications [20, 21]. Nevertheless, these approaches still often study model materials, such as single crystal slabs, rather than industrial catalysts, which contain mesopores, micropores and even nanopores, and are combinations of several different materials, including for example promotors. Furthermore, while temperature may be (slightly) increased, pressure is disregarded, or vice versa. The operando spectroscopy approach is an approach that is gaining more and more traction after its introduction approximately 20 years ago [22], particularly due to these considerations. The operando spectroscopy approach is to study a catalyst at work, under reaction conditions, and while quantifying the products in order to ensure relevance. Nevertheless, this approach is plagued (at least) by the problems 1–3 listed above.

2. Modulated excitation spectroscopy

2.1 Principles and background

A possible way to overcome these limitations is by taking the working principle of lock-in amplifiers. Lock-in amplifiers are among the most widely used general tools in physics and engineering labs, generally used to measure the amplitude and phase of an oscillating electrical system or, more specifically, to extract a very small electronic measurement signal from e.g., the utility frequency of -50-60 MHz by use of a known carrier-wave frequency. The working principle is to take the input signal along with the unwanted noise, combine it with a known reference signal and put this through a frequency mixer, after which the desired frequency is filtered out using an adjustable low-pass filter. This entire principle of mixing, and filtering is called phase-sensitive detection (PSD) [23]. This phase-sensitive detection follows the following equation [24-28]:

$$A_k^{\Phi k,PSD}(E) = \frac{2}{T}\int_0^T A\,(E,t)\sin(k\omega t + \Phi_k^{PSD}), \quad (1)$$

with A, the original signal as a function of energy E and time t, Φ^{PSD} the modulation phase angle, k the harmonic ($k = 1$, fundamental harmonic), and $T = 1/\omega$ as the demodulation period, see also Figure 2. Steps have been made to combine the methodology with relevant systems in simple heterogeneous catalytic systems, most notably by spectroscopists at the Swiss Light Source, such as Ferri and Nachtegaal [27,29].

The "phase-sensitive" phrasing stems from the principle that (aside from any component which has a different frequency than the reference signal) any out-of-phase component which has the same frequency as the reference signal is attenuated, which can mathematically be explained by the functional orthogonality of sine functions. That is, if you multiply a sine with a cosine function it is attenuated. As Fourier's theorem states that any function can be described as the sum of sine and cosine functions, one might expect the cosine to also appear in Eq. 1. However, by the addition of the phase shift and phase angle components to Eq. 1 this Fourier property can be simulated manually and therefore manipulated.

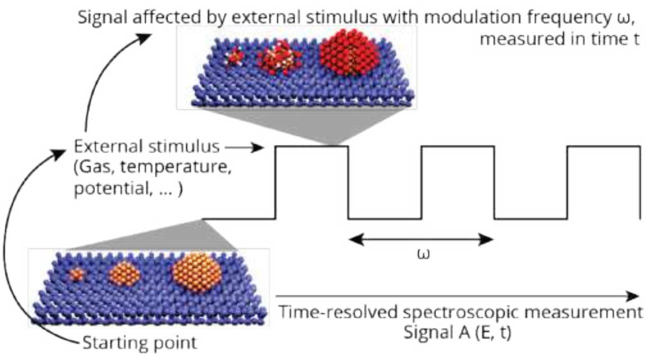

Figure 2. A scheme showing the principle behind modulated-excitation spectroscopy.

2.2 Uses and examples in catalysis

One might deduce from the explanation of the lock-in amplifier that the addition of a known reference signal to a noisy system allows for the demodulation of very small signal fractions (see point 1 in Section 1.1 above). Let the signal in this case be the convoluted spectroscopic signal from a catalytically active supported Pt nanoparticle system, and the known reference signal be a periodic excitation of this system with alternating gas pulses; O_2 and CO.

The frequency of the external stimulation ω and the demodulation phase angle Φ_k^{PSD} (which in practice is an arbitrary input) are applied leading to the attenuation of all components of the original signal that do not follow ω [30], such as the contribution of "spectator" signal (the spectral species which are present but do not partake in the reaction). For example, upon the examination of this hypothetical Pt system with hard-X-rays, we can cancel the signal from inorganic atoms that comprise the bulk of the Pt nanoparticles (in the case that they do not respond to the external gas stimulation) or, by using infrared spectroscopy, we can distinguish between vibrations from active and inactive organic catalytic intermediates thereby elucidating side reactions from the main active reaction pathways (see, for example, Figure 3).

One might imagine the difficulty in applying an exact square-wave function of gas pulses, yet as stated above this approach to demodulation still holds valid due to Fourier's theorem stating that any arbitrary function can be described by an arbitrary combination of sine and cosine functions. In essence, phase-sensitive detection is a Fourier transformation, with the addition of phase sensitivity to reduce noise. Some benefits of such analysis have already been proven by the study of basic systems such as the reversible oxidation of noble metals [30], where the sensitivity of such detection was greatly enhanced.

In the case of the application of such spectroscopies to the complex and demanding systems that are relevant to catalysis, it may have some additional benefits. For example, after demodulation, for every phase angle one obtains one demodulated spectrum, and for every higher harmonic we obtain another demodulated spectrum. In principle one should be able to use the phase angle and higher harmonic as a descriptor for the kinetic behavior of the spectral signal

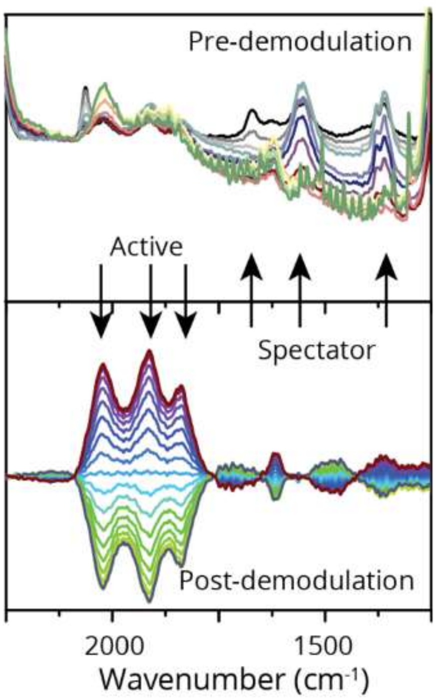

Figure 3. Schematic example of possible results with modulated excitation type experimentation. FT-IR spectra before and after demodulation, and the separation of active and spectator species. Top half of figure is reproduced with permission from reference [31].

under investigation, as the degree of attenuation is dependent on the phase offset with respect to the initial pulse onset and harmonicity. Via simulation of spectroscopic data, it was shown that transient species possessing fast kinetics are enhanced relative to those possessing slower kinetics in the fundamental harmonic [26]. As such, by examining higher harmonics one should – in principle – be able to distinguish species with faster kinetics from those with slower.

2.3 Perspective

The past two decades have seen significant improvements in the application of spectroscopic techniques such as infrared and UV-Vis spectroscopy, or X-ray absorption spectroscopy to study catalysis at work, an approach that is termed operando spectroscopy. Nevertheless, with traditional application of such spectroscopic techniques it can be very difficult to determine the most relevant information (active sites, active reaction intermediates, active phases, and even dynamic changes) due to the high degree of complexity of the catalyst-reactant matrix e.g., in terms of pressure, temperature, and material complexity. Advances in the combination of spectroscopic techniques with increasingly higher time resolution, along with e.g., operando spectroscopic reactors, digital valve control and a posteriori data analysis, offer novel overall approaches to study catalytic reactions at work. In this article some examples have been given of achievable results. In our new research group at the Technion these, and several other approaches, will be developed and applied with the overall goal of obtaining novel fundamental insights into catalytic processes and driving the discovery time of new catalysts and materials down significantly.

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ציוד כמו שלנו
אפשר אולי להשיג במקום אחר,
שרות כמו שלנו – לא.

Sidney Loeb and the origins of pressure retarded osmosis

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Abstract

In 1973, Sidney Loeb invented the process for generating power that he called Pressure Retarded Osmosis (PRO). PRO was invented under the Israeli government program of applied research for the utilization of arid climates, local raw materials and natural resources. From 2003 to 2013, a major attempt was made to develop PRO into a commercially viable power source but the project was not successful. Advances in membrane and other technologies have now led to renewed interest in its commercialization. The origins of PRO and personal recollections of the author are presented.

Introduction

Prof. Sidney Loeb (1917-2008) came to Beer-Sheva in 1967 to teach reverse osmosis (RO) technology at the Negev Institutes for Arid Zone Research, later part of the Ben-Gurion University of the Negev (BGU). Loeb is best known as the co-inventor in 1964, together with S. Sourirajan, of practical reverse osmosis, the most important method of water desalination [1]. Later, he made aliya, accepting a position at the newly established BGU. I have previously reported on this period as it relates to Loeb's work in Israel on RO. The interested reader is referred to that article Chemistry in Israel, December 2001, (8), p 8-9. In 1973, Loeb invented the process for generating power that he called pressure retarded osmosis, or PRO, at Ben-Gurion University of the Negev.

The concept of producing power from the mixing of fresh and salt water was first suggested by R. E. Pattle in 1954 [2]. Loeb invented a process to harvest this energy source.

Sid and I were close friends and we would discuss the invention. In the mid-1970's we both worked at the same research center of Ben-Gurion University. I joined the center in 1975 during the time that research on PRO was being carried out. I saw how that unique research environment combined with Sid's experience on related systems and, most importantly, his engineering genius, all came together in PRO (see Figure 1). The invention met the primary goal of the institute, *applied research for the utilization of arid climates, local raw materials and natural resources, to the benefit of both Israel and of other arid areas.*

Bob Weintraub was born in Brooklyn, New York and made aliyah in 1975 to Beer Sheva, where he remained. He earned the PhD in Physical Chemistry from MIT and the Diploma in Library Science from the Hebrew University of Jerusalem. He held positions in scientific and technical librarianship in industry, hospital and academic institutions. He is now retired. He has an interest in the history of chemistry.

Figure 1. Prof. Loeb at home in Omer in his study on his 91st birthday. On the back wall to his left is a copy of Prof. Loeb's favorite piece of art, *Waterfall*, by M. C. Escher. Loeb marked the image with the words *Free energy,* and the man in the picture at the bottom he labelled *Gibbs*. Loeb appreciated the pun on the term "free energy," its thermodynamic meaning, and that the Escher machine can produce energy for "free." Loeb told the author that the Escher illusion of a water-powered perpetual motion machine demonstrates the ideal engineering feat that he strived for his entire life. (Photograph by author)

Definition of PRO

Loeb et al. (1975): "Pressure-Retarded Osmosis (PRO) is defined as a process in which solvent (water herein) permeates osmotically against a hydraulic pressure gradient. The process is thus capable of producing energy, providing that a high osmotic pressure solution (concentrated brine herein) and a low osmotic pressure solution are simultaneously available.

"The Dead Sea appears to be an ideal and perpetual source of both concentrated brine and low osmotic pressure solution, the latter to be supplied either by the River Jordan or by brackish springs. Similar possibilities should exist at Great Salt Lake and other saline bodies of water in the world. As another possibility, saturated brine formed from the dissolution of salt mountains could possibly be used in conjunction with sea water as the low osmotic pressure solution" [3].

Request for an article on how the idea for PRO came about

In 2003, Statkraft, the Norwegian government energy company, was working on PRO and asked Sid if he would prepare an article describing how the idea came about. Sid wrote this up for them twice but each time they asked him for something less technical. Sid asked if I would prepare this, which I did, and after Sid's editing, we sent the article to Statkraft (personal communications, Nov. 2003 to Feb. 2004). That article is given below.

I recall a conversation with Sid at the time that Stafkraft first asked if he would be willing to come to Norway for a visit to advise on PRO. He told me that he was considering not going. Sid was a person who held himself up to the highest ethical standards. His recent calculations had convinced him that PRO was not economically feasible and therefore he could not in good conscience advise on the project. He said that he did not have the right to waste Statkraft's money on his expenses. I recall saying to Sid that he should not kill the PRO idea; that in 10 or 20 years another "Sidney Loeb" might come along and improve the technology and make PRO viable. Sid expressed to Statkraft his hesitation about the trip. They told him that PRO was one of several energy sources that they were studying to see which offered the best possibilities. They wanted him to advise them no matter what. Sid then decided to assist them in any way possible.

After ten years work on PRO, Statkraft in 2013 announced the decision to terminate their PRO project [4]. According to the trade publication, ForwardOsmosisTech, the reasoning behind this decision was as follows: "…there are no high performing AND CHEAP [capitals in original text] bulk PRO membranes available for purchasing today – and this situation is not expected to change within the next 5 years. Add on top of this, the huge scale of operation needed in order to drive down the actual OPEX costs of producing electricity in an osmotic power plant, and you're left with a rather bleak outlook. It is very likely this [is the] kind of reasoning that has led Statkraft to the conclusion that economical viability for osmotic power production lies too far in the future to justify further funding of their project [5]."

Advances over the past decade in membrane and other technologies have led to renewed interest in PRO. Chung and Wan (2020): "In summary, membrane technologies for PRO have come a long way since the concept was proposed in the 1950's. There have been significant progress in fabrication of novel PRO membranes, understanding of PRO mass transport, design, optimization, operation, and maintenance of various PRO processes. With several PRO processes in pilot stages, the commercialization of PRO technologies should emerge in the near future [6]."

It is now about 50 years from the time that the idea for PRO started to take shape in Sid's mind. The paper that I wrote in 2004 about the origins of PRO follows.

The origins of PRO

The research environment

One of the primary purposes for the government-run Negev Institutes was to carry out applied research for the utilization of the arid climate to the benefit of both Israel and of other arid areas. The Institutes were to use local raw materials and natural resources. Located on the same site was a branch of the Israeli Bureau of Standards and the research division of the Dead Sea Works.

From 1960 to 1970, Israel's energy consumption almost tripled, for which crude oil was the only primary source. Electricity output was based entirely on oil. Oil prices began to rise steeply in 1970. Construction of a canal connecting the Mediterranean Sea – Dead Sea - Red Sea was first proposed already in 1855 by William Allen as a cheaper alternative to the projected Suez Canal. Over the years, the proposal changed in form and intended goals, but at the heart of all of the proposals was always to make use of the 400 meter drop in altitude to the Dead Sea from the other bodies of water. Benefits to be derived from the proposed canal included transportation, hydroelectric power, elevation of the Dead-Sea level to meet the needs of industry and tourism, provision of cooling water for inland nuclear reactors and industry, creation of sea-water based inland industries – for example, fish ponds, inland lakes to promote tourism, and the production of fresh water by reverse osmosis.

The idea

Sidney Loeb was then in this environment where he was in touch with these ideas. The campus was active in research in three areas that all were to come together in Sidney Loeb's mind in the form of PRO – energy, membranes, and the utilization of Israel's arid zone natural resources – in particular the Dead Sea. However, Loeb's original patent (see last paragraph) mentions the combination of river water and sea water as a parallel possibility.

Further to this, if one were to make a movie of an operating RO plant and run the film backwards, we would have what looks like an operating PRO plant. In viewing the film running in the forward direction we would see an RO plant where one stream of salty water is entering the facility and two streams are leaving it – one fresh water for drinking and one more salty waste water. Energy is consumed in this osmotic process. If we were to view that same film in the reverse direction, we would now see two streams of water entering the facility, one of higher salt content than the other, and one stream leaving the plant. Energy is now being produced osmotically. Stated another way, as energy is required to desalinate water, then salination can be used to produce energy. As one can appreciate, Sidney Loeb, already in tune with RO, was ready and able to make the conceptual leap from RO to PRO.

A colleague remembers

Dr. Melvin Weintraub [no relation to author], a biochemist working with Sidney Loeb at around that time, recalls as follows:

"I imagined that Sid thought of the process just by trying to see how membrane technology could fit in economically with power needs. This connection has always been the driving force for membrane technology, since you achieve the separation you want without a phase change, which saves a lot of energy and thereby, cost. With reverse osmosis, we are always concerned about fouling effects such as concentration polarization, and how to prevent or alleviate them. I imagine that while thinking about these things Sid may have been thinking if there was a way to use such effects to our advantage. That's what a clever engineer would do. And, I suppose, he came up with pressure retarded osmosis out of that. It's simple enough once you are smart enough to turn the problem around" (personal communication, Feb., 2004).

Jordan River and the Dead Sea

Loeb's first thought was to use PRO to harness the power from the free energy of mixing of the Jordan River with the Dead Sea (see Figure 2). However, the Jordan River did not have a large enough flowrate to be useful for PRO. It is curious to note that among the other possibilities for application of PRO covered by the patent, Loeb also considered capturing the free energy of mixing for the production of power by "another" Jordan River as it runs into the Great Salt Lake of Utah. Prof. Loeb filed his first patent application on PRO in Israel on July 3, 1973, application number 42658 (This is shown as erroneously as July 3, 1974 on the front page of the US patent). The patent was issued on December 1, 1976. A United States patent application was filed on June 19, 1974, and the patent was granted as US 3,906,250 on September 16, 1975. The patents were assigned to the Ben-Gurion University of the Negev.

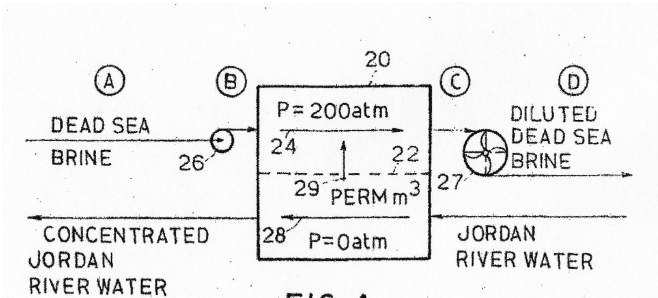

FIG. 4

Figure 2. Diagram from [United States Patent 3,906,250.](#) Sept. 16, 1975. Method and Apparatus for Generating Power Utilizing Pressure-Retarded-Osmosis. Inventor Sidney Loeb. Figure shows flow diagram for using PRO with the Dead Sea/Jordan River pair. Detailed explanation can be found in the patent.

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Interview with Abraham (Avi) Domb – Chief Scientist of the Israel Ministry of Innovation, Science and Technology

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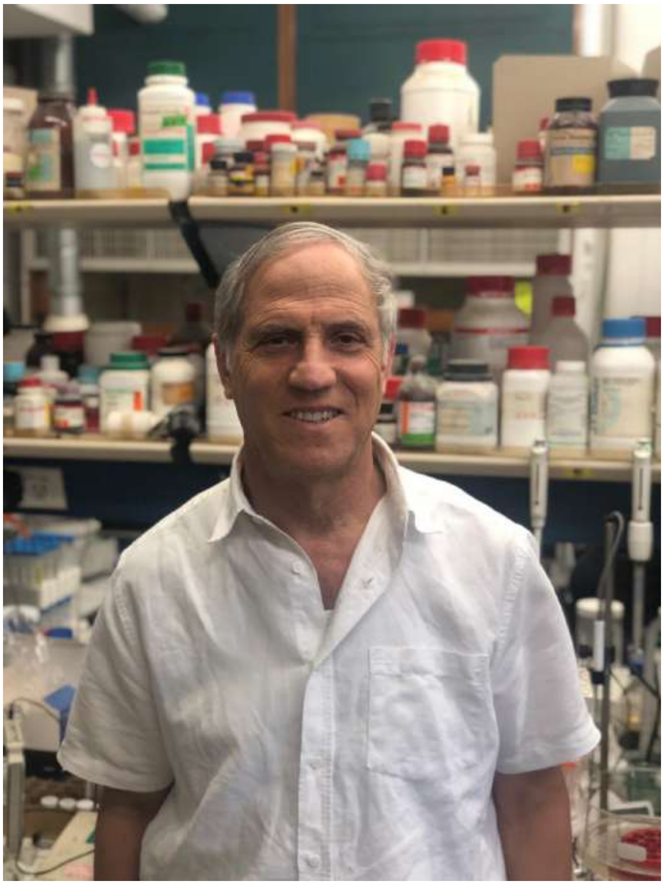

Q: Where were you born and where did your parents come from?

A: I was born in Ganei Zvi, now part of Hod Hasharon. Both of my parents came from Poland.

Q: What inspired you to study chemistry?

A: I went to high school in Kfar Haroe Yeshiva, where I had a great chemistry teacher, the late Prof. Moshe Adad. He instilled in me a love for chemistry. By the way, Prof. Adad was later a Prof. of Criminology at Bar-Ilan Univ. Later, when approaching university studies, my twin brother Menahem and I decided to go in different directions. He studied mathematics and computer science. I chose chemistry.

Q: Why did you choose your particular field of chemistry?

A: When looking for a field in chemistry to focus on, I was fascinated by the diversity of polymer chemistry and applications. I started MSc studies at the Casali Institute at the Hebrew University on Polymers and Textiles, a joint program with the Fiber Institute in Jerusalem. After one year, I was introduced to Prof. Yair Avni and Prof. Zilcha from the chemistry department and decided to move to Yair's lab to proceed to a direct PhD on "Functional Polymers". Within

Arlene Wilson-Gordon was born in Glasgow, Scotland. She completed her BSc (Hons) at Glasgow University and her DPhil at Oxford University under the supervision of Peter Atkins. After a postdoc at the Hebrew University withRaphy Levine, she joined the faculty at the Department of Chemistry, Bar-Ilan University, where she rose to the rank of Professor and in 2015, Professor Emerita. Her research interests lie in the field of theoretical quantum and nonlinear optics. She is the editor of the Israel Chemist and Engineer, an online magazine for all who are interested in chemistry and chemical engineering.

polymers, the field of biopolymers for implants and drug delivery had just started, so I decided to study pharmacy to better understand the medical needs. While doing my PhD, I studied pharmacy at the School of Pharmacy as an undergraduate student and completed both in 1984. I moved to Syntex Co., California for postdoctoral training, working on a hydrogel implant for a one-year delivery of the hormone LHRH for treating prostate cancer. After one year, I moved to Langer's lab at MIT and Folkman's lab at Children's Hospital, Harvard Medical School, working on the design and synthesis of biodegradable polymers for tissue engineering and carriers for controlled drug delivery.

Q: You have held a variety of positions from University Professor to College President to Head of Forensic Science in the Israel Police and now Chief Scientist at the Ministry of Science and Technology. Can you describe these roles and what attracted you to them?

A: After three years of postdoctoral training in the US, I worked for one year at the Biological Institute in Ness Ziona and then moved back to the US to become director of R&D at Nova Pharmaceuticals Co. in Baltimore. After about three years, I was looking for a job in Israel. An academic position was a distinct possibility. I received an offer to join the School of Pharmacy of The Hebrew University at the Hadassah Hospital in Ein Karem, a perfect place to carry out applied medical research. In 1997, I completed a diploma in Business Administration and in 2007 Law studies, both from Hebrew University. Coincidently, I was approached by the police with an offer to head the Division of Identification and Forensic Sciences (MAZAP), in charge of 15 forensic labs and 450 employees. I thought that this would be an interesting opportunity, took a leave of absent from the university, and joined the Israel Police with the rank of Brigadier General. After about five intensive years during which time I learned a tremendous amount about forensic science, management, and public service, I moved back to the university. During my years in the Israel Police I kept my lab active, thanks to my graduate students, Boaz Mizrahi and Shady Farah (both now professors in the Technion). In 2014, I was approached by Uzi Wexler, founder and president of Azrieli College of Engineering, to become president, which I did in parallel to my university duties. This was an opportunity to understand the importance of engineering and its role in translating science into practice. In 2018, I was elected head of the School of Pharmacy with the objective to increase the number of pharmacists in light of the shortage of pharmacists in Israel. The position Chief Scientist came up with no intention on my part. This position is an opportunity to promote applied academic research to achieve important national needs and increase academic involvement in government programs and industry.

Q: Which role gave you the greatest satisfaction?

A: The position at the Israel Police. The forensic division is responsible for the national forensic activities, serving not only the police but also security and government agencies. The position requires operation of forensic laboratories with a staff of about 200 scientists, most with MSc in addition to 20 PhDs and about 250 field investigators. The labs are equipped with up-to-date instrumentation and technologies in diverse scientific fields: biology, chemistry, physics, engineering, and computer science. Most important for me was the opportunity to meet policemen of different ranks and positions. These policemen work hard and in harmony towards the wellbeing of all of our citizens.

Q: Do you enjoy teaching and interacting with students?

A: I very much enjoy teaching and interacting with students. I teach in two faculties, the Faculty of Medicine – School of Pharmacy where I teach medicinal and organic chemistry, biopolymers, and pharmaceutics, and the Faculty of Law where I head the MSc Program in Forensic Sciences. I have graduate students in both faculties studying biopolymers, medicinal chemistry, pharmaceutical sciences, and forensic science.

Q: What do you consider to be your greatest scientific achievement so far?

A: Synthesis and applications of biodegradable polymers, particularly the polymers that are in use in Gliadel, Inspace, and Bioprotect products and in Intragel and Gentagel-LR products that are under development.

Q: What do you consider to be your greatest contribution to Israeli society?

A: My contribution to professional education, teaching and supervising hundreds of undergraduate and graduate students who today hold positions as pharmacists, industrial R&D staff, and academic positions.

Q: Would you recommend a career in academia to young scientists?

A: Absolutely – to individuals who see science as part of their life, are willing to spend long hours reading, writing, and researching in a lab. An academic position provides the freedom to perform research in various fields, associate with the international community of scientists, collaborate with industry, and even establish companies and enjoy royalties.

Q: What are the main challenges facing Israeli science?

A: Excellence in science requires a talented work force – faculty and students, a proper scientific infrastructure, up-to-date instrumentation, and lab resources. To remain relevant in today's fast growing and highly competitive international academic environment, support from government is essential. Beside excellence in basic science, academia should contribute more to functional science that leads to science-driven industrial development, while training the best graduate students who should proceed to applied research. As Chief Scientist, my intention is to promote applied research of national preference, leading to more start-up companies and licensing technologies that originate in universities and research institutes.

Q: If you had a magic wand, what would you change in a) in academic life, b) in Israeli society?

A: Academic research must continue to be competitive, excellent, and innovative at an international level. The universities and colleges have a role is training the science-driven workforce, thus, the academic ecosystem should promote applied research as a continuation or part of basic research. Efforts should be made to encourage all communities in Israel to be part of the science and technology revolution.

Q: Do you have any advice for young people embarking on their career?

A: Any individual who proceeds into the scientific community should choose what they would like to do for life but remain open to new opportunities. Diversification in education and job opportunities should always be considered at any time point during a scientific career.

Q: How do you enjoy your free time?

A: These days my free time is used for exercise and enjoying my family and grandchildren.

Women in science

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Abstract

Women continue to represent a small proportion of faculty members in science and technology programs, especially in more prestigious research institutions. They still need to cope with discrimination, with an **unconscious bias,** as well as with the demands of their families. According to UNESCO institution of Statistics, fewer than 30% researchers all over the world are women. The analysis of *"A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences, How to measure it? How to reduce it?"* survey, contributed to the understanding of this phenomenon and to the identification of the various factors causing it**.** The recommendations address a variety of groups: instructors and parents of girls in primary, secondary, and higher education; educational organizations; Scientific Unions and other worldwide organizations. This paper will deal with the situation of women scientists in Israel, with examples of women chemists in academia.

1. Introduction

At a symposium on women in science, conducted at the Israeli Academy of Sciences and Humanities on April 23rd, 2003, Professor Ruth Arnon, a biochemist and co-developer of the multiple sclerosis drug Copaxone, from the Weizmann Institute of Science, Israel, claimed [1]:

> *After all, scientific research is an occupation that relies on personal skills (talent, perseverance, executive ability, etc.) and does not depend on the gender of the practitioner. And therefore, why dedicate the discussion to women scientists only? But it turns out that what is true in theory is not always true in reality. For ages, female scientists were not given the right of an equal among their fellow male scientists. Therefore, we thought that there was room to discuss the issue of women in science in Israel, and precisely within the walls of the Israeli National Academy of Sciences.*

At the same symposium, Dr. Pnina Abir-Am from Rockefeller University [2] gave a *historical* overview about the participation of women in science, since the Scientific Revolution in the 17th Century. Women only participated as collectors, illustrators, translators, or assistants of scientist family members. The establishment of women's colleges in the last third of the 19th Century enabled science education for women (e.g. Marie Curie). Even today, despite various improvements and a rise in the number of women students of science, women are still a minority in many fields of science – underrepresented in positions of leadership in universities, scientific societies, or industries.

Dr. Rachel Mamlok-Naaman was the head of the National Center of Chemistry Teachers at the Weizmann Institute of Science (until 2020), and the coordinator of the chemistry group at the Department of Science Teaching (until June 2016). In addition, she serves as the chair of DivCED EuChemS, a titular member of the IUPAC committee on chemical education (CCE), and an executive member of the IUPAC gender gap committee. Her publications focus on the topics which are related to students' learning (cognitive and affective aspects of learning), and on teachers' professional development. She received several awards, among them - two from the Weizmann Institute: the 1990 Bar-Ner award for teaching, and 2006 Maxine Singer award for professional development of science teachers. In 2018, she received the ACS award for incorporation of sustainability into the chemistry curriculum, and in 2020 the IUPAC award for distinguished women in chemistry or chemical engineering.

Blickenstaff [3] claims that women are not represented enough in science technology, engineering, and mathematics (STEM) disciplines in not only the United States, but also in most other countries around the world, despite the advancements in science and technology. Women continue to represent a small proportion of faculty members in science and technology programs, especially in more prestigious research institutions. For STEM women faculty, for example, academic tenure often coincides with their child-bearing years. With decreased lab space, inadequate resources, lower salaries, and fewer prestigious opportunities, early stages of an academic career are particularly difficult for women. They still need to cope also with discrimination, an **unconscious bias,** and the demands of their families.

Makarova, Aeschlimann, and Herzog [4] conducted a study in which they investigated the impact of the masculine image of three school subjects – chemistry, mathematics, and physics – on secondary students' career aspirations in STEM fields. The data was collected from a cross-sectional study among 1364 Swiss secondary school students who were close to obtaining their matriculation diploma. The findings suggest that gender-science stereotypes of math and natural sciences may influence young women's and men's aspirations to enroll in a STEM major at university.

According to UNESCO Institution of Statistics [5], fewer than 30% researchers all over the world are women. A three years' global project (2017-2019): "*A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences, How to measure it? How to reduce it?*" was funded by the International Science Council and involved eleven scientific partner organizations [6] . The main goal of the project was to investigate the gender gap in STEM disciplines from different angles, globally and across disciplines. The project consisted of (i) a global survey of scientists with more than 32,000 responses; (ii) an investigation of the effect of gender in millions of scientific gap in Mathematical, Computing, and Natural Sciences at various levels.

Chiu and Ceca [7] analyzed the results of the global survey disseminated to 32,000 scientists, of which 50% were male and 50% female. They showed how it contributed to the understanding of the gender gap, and to the identification of the various factors which cause it**.** Its results confirm that the Gender Gap in Science is very real: it exists across all regions, disciplines, and development levels. Women's experiences in both educational and employment settings are consistently less positive than men's. Recommendations for improving the situation were based on the survey's findings. The recommendations address a variety of groups: (1) instructors and parents of girls in primary, secondary, and higher education, e.g., to avoid books and social media that reinforce the gender gap in science; (2) educational organizations, e.g., to avoid books and social media that reinforce the gender gap in science; (3) scientific unions and other worldwide organizations, e.g., to encourage the presence of women in editorial boards in their disciplines and publish reports on the proportion of papers published by women.

Discrimination can be also found in the publication data [8]. A Survey of Doctorate Recipients [9], and the National Study of Postsecondary Faculty [10] deal with questions about career progression, such as self-reports of faculty persons and the number of their publications, a measure of productivity. The findings show that women are less likely to be promoted with tenure, even after controlling for number of publications [10].

Weisshaar [11] claimed that publication measures show gender bias, expressed through work on self-citations. Publication data were retrieved from Google Scholar using a Python script. She created multiple variables to measure both the quantity and quality of research productivity – number of journal articles, books by type (research monographs, textbooks, and edited volumes), book chapters, and (for Computer Science) conference presentations. She measured the quality/visibility of research productivity with three measures: (1) a binary variable that is coded as 1 if the professor has published in the highest-prestige journals in their discipline, (2) a variable that reflects the cumulative percentage of first-authored and single-authored publications. Each of the above productivity variables were measured at three time periods: 1) the five years prior to beginning an assistant professorship; 2) the years in which the person served as an assistant professor; and 3) the year after a tenure decision is made.

2. Science and women chemists in Israel

Prof. Hagit Messer-Yaron, an electrical engineer from Tel Aviv University, chairperson of the Council for the Advancement of Women in Science and Technology, established by a government decision in 2000 [12] , and Prof. Hadassah Degani from the faculty of biology at the Weizmann Institute of Science [13], who participated in the symposium mentioned above focused on interesting aspects of women in science in Israel. Messer-Yaron [12] presented the percentage of women engaged in science and technology in Israel. She said that it does not exceed ,25% while women are about 45% of the labor force in Israel, and about 55% of university graduates. Women who choose to work in scientific fields encounter a glass ceiling, in academia as well as in industry, so that the percentage of women decreases. In the highest ranks (full professor) it is slightly less than 10%. In order to improve the situation, The Council for the Advancement of Women in Science and Technology coordinates national activities on this issue in coordination and cooperation with the European Community. It should be noted that the chemistry field is less “masculine”. There are more than 60% female students studying for BSc and MSc degrees, and more than 50% for PhD but, still, faculty women are ~ 10%.

Degani [13] referred to the situation of women in science in Israel, and said that there is huge progress in women’s science education but, still, women are not eager to be the chairs of science and biotechnology faculties in academia or in industry. Most women with a PhD are struggling with sharing their time between family and career, and in many cases they make career concessions on the professional level.

Arnon [14] said that, although among the students studying at universities and colleges for all three degrees, women make up more than half, in the faculty of universities in Israel, women make up only 29%! This figure is considered particularly low compared to Western countries where the percentage of faculty members is about 40%. Out of 31 countries examined, Israel is ranked 30th! The glass ceiling is a common phenomenon in Israel. Also, the higher the rank, the lower the percentage of women among the academic staff – the well-known scissors phenomenon. The glass ceiling is a common phenomenon in Israel. Women make up only 16% of full-time professors at universities, a lower-than-average rate in Western countries.

Regarding the physics discipline, Jona and Nir [15] claim that about one third of those who study physics at high school are girls. This drops down to about 16% of female students at the first, second, and third university degrees, and then drops further down to about 7% of academic staff. During the last few years, universities in Israel initiated a few programs, aimed to promote gender balance but, still, it is not possible to assess the success of these programs in improving gender balance.

2.1 Examples of programs of enhancing women scientists’ career in two academic institutions in Israel

The examples of programs aiming to enhance women scientists’ careers will refer to two academic institutions in Israel: The Weizmann Institute of Science, and the Israel Institute of Technology (Technion). These two institutions were chosen, since both of them are world-class multidisciplinary science and technology research institutions.

2.1.1 Enhancing women scientists’ career at the Weizmann Institute of Science [16].

The Weizmann Institute of Science gave priority to the development of the careers of **women scientists.** Following are a few examples:

- Offering national postdoctoral award program for advancing women in science
- Offering comprehensive information on scholarships for Master’s and PhD students, as well as postdocs, including travel scholarships, excellence scholarships, and scholarships for advancing women in science.
- Hosting a variety of activities for female students (MSc students, doctoral students and postdocs), including a mentoring program. Students are matched with female scientists who can provide support and encouragement in all matters concerning career advancement and direction.
- Celebrating women researchers by providing a snapshot of the research world through their eyes. In their essays, the authors tell some of their personal stories, and share the challenges and successes that were significant in their careers. One of the celebrations was dedicated to Ada Yonath, a distinguished woman chemist from the Weizmann Institute of Science. She was awarded the 2009 Nobel Prize for Chemistry, along with Indian-born American physicist and molecular biologist Venki Ramakrishnan and American biophysicist and biochemist Thomas Steitz, for her research into the atomic structure and function of cellular particles called ribosomes [17].

2.1.2 Enhancing women scientists’ careers at the Israel Institute of Technology

In 2016, the Technion held the first conference for outstanding female high-school students from all over Israel “Tech Women 2016” [18]. Attended by 670 high-school students, the conference was designed to encourage female students to pursue higher education in science and engineering. This first conference was held in honor of International Women’s Day in March. It was supported by the Rosalyn August Girls Empowerment (GEM) Mission, which was launched by Rosalyn August Girls Empowerment Mission (GEM) at the Technion in 2016. There are presently over 5,000 female students at Technion, and 32% of the master’s students and 44% of doctoral students at the Technion are women.

> *TechWomen 2020: 6th TechWomen event - featuring “X-Men”, and the Israel Security Award* [19]

Three hundred outstanding female high school students in science and mathematics attended a virtual event which showcased an array of opportunities flowing from academic studies in science and engineering at the Technion. The event was held courtesy of the Rosalyn August Foundation for the Empowerment of Young Women. August, who lives in Florida, greeted the students from her home, telling them: “I have always felt that women could do whatever they want. I believe in you and your leadership to change the world. You have talent that many women long for, and you are an inspiration for me. You are the future of the world. I salute you, and I will continue to support this important event."

Advancing Women in STEM at the Zuckerman STEM Program [20]

The Zuckerman STEM Program leads the way in advancing women in STEM in academic institutions. 64% of the 2020-2021 Zuckerman Scholars are women. Each Zuckerman female scholar is making an impact in her field, creating a larger group of her peers and making it easier for other women to be accepted as faculty members.

3. Personal perspective

My research can be described as a *spiral* procedure, referring to the diverse facets of chemistry education, which are largely integrated with one another. The findings on student learning and motivation guided (and guide) me in designing and revising curriculum materials and professional development (PD) programs for chemistry teachers, since they are the key to the success of their students, implementation of new curricular materials, and reforms in education. Therefore, I always put a lot of emphasis on research regarding chemistry teachers' professional development. I myself was a chemistry teacher for 26 years, part of them – parallel to my work at the Weizmann Institute.

My acquaintance with the education system helped me in planning and conducting professional development programs in cooperation with science educators in Israel and abroad. I felt the importance of stressing the point of education through science / chemistry, and not just teaching or learning chemistry. It gave me a huge satisfaction to work with teachers from all over the world, and to try to influence their attitudes towards the way in which chemistry should be taught, as well as their motivation to perform changes in their teaching strategies, e.g., planning lessons in which every individual student will be able to express themselves, and get the opportunity to understand chemistry.

My experience over the years convinced me that loving my profession, and believing in what I am doing, are the main components to success. The passion to research a domain in which I am involved with my mind and with my soul, kept me moving on even when I faced difficulties. Science education research in general, and chemistry education in particular, are composed of many different aspects: curriculum, teachers, students, policy makers, etc. It is always recommended to focus on not too many aspects. However, a researcher should be acquainted with the other components. The process may be full of handicaps! I myself faced quite a lot of challenges, including personal family constraints. However, I was persistent, loved my research and my practical work, developed self-efficacy, and believed in my ability to make a change.

4. Summary

Despite marked advances towards gender equality and empowerment of women, especially during the last century, progress has been slow and disparities persist around the world. Unfortunately, science is not immune to such inequalities, with women representing only a third of researchers globally and often facing gender-based discrimination and a lack of equal opportunities. In order to change the situation, it is necessary to act on both the educational and economic level [21].

Barnard et al. [22] suggest that women have to be able to adopt strategies of survival, and conform to their environment. Otherwise, they may be isolated, accept lower paying positions. They suggest creating social networking groups in order to support women with becoming accepted into the science community. In addition, women should promote themselves and their research on a broader spectrum, and enhance their collaboration and informal mentorship.

At the educational level, there should be a change in the belief that having a family clashes with making a career, as suggested by Wolfensberger [23]. There must also be a significant change in attitude regarding the responsibility for the family members. The educational process should begin from an early age in order to encourage women who decide to combine family life and a scientific career. Women who succeed in this process, and who get support from their families, may serve as a role model to other women. Moreover, supporting young women scientists in their career development is crucial at both professional, economic, and personal levels. The Nordic countries may serve as prime examples for family policy aimed at a gender-equal division of economic responsibility, and focusing on fathers' participation in childcare [24].

In summary, the gender gap is a problem of society (women and men). Reducing the gender gap is a major challenge for the whole scientific community, in developed as well as developing countries, and concerns everyone, men and women. The International Science Council (ISC) funded a unique three-year project in 2017–2019 called, "A Global Approach to the Gender Gap in Mathematical, Computing and Natural Sciences: How to measure it, how to reduce it?" that has provided a wide-ranging view of the issues women face in the sciences and how these issues may be overcome [25]. As mentioned above by Chiu and Ceca [7], the survey led to several recommendations, which may be summarized as: (1) We should actively promote gender balance at every level of any organization, including its leadership, committees and also institutional events, and (2) We should raise the awareness of the gender gap and include specific actions that aim at reducing it, in all outreach and educational programs and products.

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The 2021 ICS Prize Ceremony: July 1, 2021, The Open University, Ra’anana, Israel*

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Introduction

The Israel Chemical Society (ICS) Annual Meeting (ICS) has a long history since 1933. It is a well-known event in the scientific landscape of the State of Israel. These colorful gatherings of Israeli chemists usually occur in mid-February, which is the inter-semester break for all Israeli universities at the end of the short rainy season. The chemistry departments of the six major research universities used to share the responsibility for organizing these meetings in a 6-year cycle in a constant order: the Hebrew University of Jerusalem, Technion – Israel Institute of Technology, Tel Aviv University, Bar-Ilan University, Ben-Gurion University of the Negev, and the Weizmann Institute of Science. Following a recent decision made by the ICS General Assembly, the Department of Chemistry at Ariel University will join this cycle in a few years and organize the 89th ICS Meeting.

Over the past 25 years, the ICS has followed a unique tradition, which has attracted much attention and interest worldwide, namely hosting high-profile delegations of distinguished scientists from top academic institutions worldwide to deliver plenary and keynote lectures. This tradition has created outstanding opportunities for many Israeli scientists, particularly graduate students, to interact with world-renowned chemists, thus enhancing networking and scientific collaboration prospects. Each visit of these delegations has created a long chain of activities, including mutual visits of students and faculty members, postdoctoral and sabbatical programs, joint research proposals, and other fruitful international programs.

The first delegation on this path came from The Scripps Research Institute (1997). It continued with the California Institute of Technology (1998), the University of Cambridge, UK (1999), ETH – Zurich (2000), Columbia University (2001), the University of California at Santa Barbara (2006), the Max Planck Society (2009), the Chemical Society of Japan and the Japan Society for the Promotion of Science (2010), Academia Sinica (2011), the University of California at Berkeley (2012), the University of Oxford (2014), Stanford University (2015), five universities from Texas (2016), the German Chemical Society (2017), the Royal Netherlands Chemical Society (2018), MIT (2019), and Yale University (2020). We were fortunate to hold the 85th Meeting on February 18–19, 2020, just a few days before international conferences fell victim to the Covid-19 global pandemic. That meeting, organized by the Institute of Chemistry of the Hebrew University of Jerusalem, was held at Jerusalem’s International Convention Center with a delegation of 10 outstanding professors and 20 graduate students from Yale University.

Unfortunately, the lingering pandemic with its restrictions on international travel and public gatherings forced us to postpone the 86th ICS Meeting, initially planned for February 2021 with a large delegation from China to February 2022. Nevertheless, we refused to give up on awarding the already-announced ICS prizes. Because most Israeli citizens were already vaccinated, the Israeli government permitted limited public gatherings and events. Therefore, we decided to hold an independent prize ceremony, including one plenary and two keynote lectures.

The Venue

The Open University of Israel (OUI) hosted the event on its beautiful campus in Ra’anana at the Chais Auditorium. The OUI differs substantially from the other eight universities as it is a distance-education university, awarding undergraduate and graduate degrees in a wide range of disciplines.

In 1970 the Minister of Education and Culture, the late Yigal Alon, and the Council for Higher Education (MALAG) appointed a committee headed by Prof. Shneior Lifson of the Weizmann Institute of Science to examine ways to expand higher education following the rapid growth of Israel’s

*For the full report, see: http://doi.org/DOI: 10.1002/ijch.202100095 population, immigration, and urbanization. The committee recommended establishing a distance-education system based on the Open University of England model. In 1974 the OUI was founded on a temporary campus in Ramat Aviv. Thirty years later, it moved to the Dorothy de Rothschild Campus in Ra'anana, designed by the architect Ada Carmi-Melamed (Figure 1).

Figure 1. A general view of the Dorothy de Rothschild Campus of the OUI in Ra'anana.

The unique features of the OUI include open admission regardless of prior academic qualification and without any entrance examination. It offers distance-learning programs that utilize advanced e-learning technologies and face-to-face tutorials conducted in sixty study centers throughout Israel. The senior faculty members carry out intensive research programs in collaboration with scientists at the research universities. These activities are a crucial factor in their recruitment and promotion.

In 1976, the OUI offered five courses to its 2267 enrolled students, and the first graduation ceremony was held in 1982 with 41 graduates. Two decades later, nearly 20,000 students registered to over 300 academic courses in the humanities, social sciences, natural and life sciences, mathematics, and computer science, and 350 graduates received their BA degrees. Today, the university has more students than any other academic institution in Israel. Nearly 50,000 students enroll annually, taking more than 700 courses towards undergraduate degrees, postgraduate degrees, diplomas, and certificates. In terms of student numbers, the OUI is the largest university in Israel.

The diverse student body represents a cross-section of Israeli society, including individuals who work full time and support families, people from the geographic and socio-economic periphery. It includes gifted high school students, professionals seeking advanced degrees, ultra-Orthodox men and women, Israeli Arabs, students with disabilities, soldiers on active duty in the IDF, students with special needs, prisoners, and people outside Israel. Since 2013, the Ministry of Education launched the High School Academy Program, enabling high school pupils to take higher education courses at the OUI.

Over the years, the Open University has launched about 60 study centers throughout the country. The Integration of Distance Learning Technologies Center at Shoham develops and assimilates pedagogical solutions in academic courses using advanced technologies. The OUI has recently launched three research institutes: the Institute for the Study of Innovation in Learning Technologies, the Institute for Policy Analysis, and the Institute for the Study of Relations between Jews, Christians, and Muslims. In addition, it established several research centers, including the Open Media and Information Laboratory, the Astrophysics Research Center, and the High-Performance Computing Center.

Opening Ceremony

The event started with a one-hour welcoming reception and a light buffet dinner in the foyer of the Chais Auditorium. All prize winners were accompanied by family members, colleagues, and coworkers (Figure 2).

Prof. Ehud Keinan, President of the ICS, welcomed the audience (Figure 3): "Good evening, everybody, and thanks

Figure 2. Collage of random photos that reflect the general atmosphere of the reception of ICS Prize Ceremony. Photographs by Itzick Biran.

Figure 3. Collage of random photos taken at the Opening Ceremony and lectures. Photographs by Itzick Biran.

for coming to this hybrid event. It is all photographed, and many people watch it in Israel and abroad. Therefore, we do it in English, although Hebrew would be more convenient for most of you. The ICS started in 1933, and throughout our entire history of 88 years, we have never skipped an annual meeting. There were many excuses to skip yearly meetings due to major wars and other circumstances, but we have never done. Now, this pandemic forced us to postpone the 86th Annual Meeting, which is under the responsibility of the Technion with Charles Diesendruck and Saar Rahav as chairpersons, to February 22–23, 2022. We plan to host a vast delegation of 10 professors and 20 graduate students from Peking University and the Chinese Academy of Sciences. Nevertheless, we have decided to hold the ICS Prize Ceremony, and I am happy that we could make it.

This year we recognize 24 prize winners, and two of them have already received their prizes, so tonight, we'll award 22 prizes (Figure 4). Last week, on June 23, I awarded the Barry Cohen Prize to Prof. Daniel Rauh at the annual meeting of the Medicinal Chemistry Section (MCS–ICS), which took place online. Two weeks ago, on June 16, I awarded the Honorable Member recognition to Prof. Albert Zilkha in an actual ceremony in a small synagogue, Mishkan Shmuel, in Giv'at Mordechai in Jerusalem. Albert is now 88 years old. His physical limitations don't allow him to travel a long distance from his home, so we decided to do a special ceremony for him in the presence of his family and his former students, many of whom are themselves over 80 years old.

I wish to comment on the reason for giving prizes, as I am involved with several prize-awarding organizations, including the Federation of Asian Chemical Societies (FACS), the European Chemical Society (EuChemS), IUPAC, the Wolf Foundation, EMET Prize, Harvey Prize, and others. This year we are proud and happy that two Israeli scientists, Meir Lahav and Leslie Leizerovich, received the Wolf Prize in Chemistry. There are two main reasons for awarding prizes. The first one is obvious, recognizing the achievements of prominent scientists. The other reason, which I consider more important, is the need to identify heroes and role models for the young generation and attract young people to pursue their careers in science and technology.

I wish to comment on the ICS and the importance of chemistry for the State of Israel. When our society was founded in 1933, Jerusalem was very far from Tel Aviv, a ride of 2–3 days, not just 40 minutes in today's terms. Therefore, the ICS had three chapters in Tel Aviv, Jerusalem, and Haifa.

Chemistry plays a crucial role in Israel's national economy. Nearly 8000 chemists, 5000 chemical engineers, and 700

Figure 4. A traditional ICS autographed poster, displaying all laureates of the ICS prizes.

chemistry teachers are responsible for the fact that chemicals account for 40 % of Israel's industrial production and 25 % of its exports. Six Israeli scientists have won the Nobel Prize in sciences, all of them in chemistry. Two presidents of the State of Israel were scientists and both professors of chemistry.

Finally, I want to thank many Open University people for hosting this event free of charge: OUI President, Prof. Mimi Ajzenstadt, Dean of Research, Prof. Ofer Reany, Project Manager Asaf Shambi, and many others. I am so happy with our choice to hold the ICS Prize Ceremony in this lovely place. Many thanks also go to our administrative manager, Ms. Ayelet Baron. And thank all of you for coming to celebrate with our prize winners."

Prof. Mimi Ajzenstadt, President of the Open University of Israel, greeted the audience: "The Open University is happy to host the 2021 Israel Chemical Society award ceremony. This is the first event of its kind in which the Open University is taking part, and we hope that this type of cooperation will become a tradition in the future.

The Open University is pleased to sponsor the ceremony, which will present a wide range of award winners, including high school students who participated in a chemistry research project, chemistry teachers, administrators involved in chemistry, chemistry students, young researchers, and senior scientists who contribute to science and to the community.

The awarding of prizes and recognition of a wide range of scientific excellence is consistent with the Open University's mission. We strive to make academic knowledge accessible to diverse populations through the development and integration of learning technologies in science teaching and the support of scholarly research.

Research at the Open University encompasses the humanities, social sciences, and exact sciences. The Ra'anana campus serves all its faculty members via its infrastructure to develop learning technologies and the Shoham Center for Technology in Distance Education.

Although the campus does not have research systems, we offer technological frameworks such as the High-Performance Computer Center (HPC) and the Media and Digital Laboratory. Many researchers in psychology, natural and life sciences, and computer science are hosted by other universities with research infrastructure that suits their needs.

In addition, the Open University awards more than 2,500 graduate degrees in the humanities and social sciences each year, and our goal is to expand to more advanced degrees in the exact sciences as well.

Finally, I would like to congratulate the President of the Israel Chemical Society, Prof. Ehud Keinan, who made the courageous decision to hold the ceremony despite the uncertainty of the situation, using an online framework to allow the conference to occur in a hybrid manner. To all the winners, I wish continued research excellence."

Plenary and keynote lectures

Prof. Doron Shabat of Tel Aviv University, the winner of the ICS Prize for the Outstanding Scientist, lectured on "Functional Molecular Systems: From Drug Delivery to Signal Amplification and Aqueous Chemiluminescence." Prof. Shmuel Carmeli of Tel Aviv University moderated the lecture. Shabat has demonstrated that molecular amplification is a practical approach to various applications in science. His group has developed the most powerful chemiluminescence-dioxetane luminophores synthesized to date, suitable for use under aqueous conditions.

Prof. Menny Shalom of the Ben-Gurion University of the Negev, the winner of the ICS Prize for the Outstanding Young Scientist, presented a keynote lecture on "Carbon Nitride Materials for Photoelectrochemical Cells." Prof. Ofer Reany of the Open University of Israel moderated the talk. Prof. Shalom introduced new approaches to growing graphitic carbon nitride (CN) layers with altered properties on conductive substrates for photoelectrochemical applications. He discussed the growth mechanism of CN materials and their chemical, photophysical, electronic, and charge-transfer properties.

Prof. Norman Metanis of the Hebrew University of Jerusalem, winner of the ICS Prize for the Outstanding Young Scientist. Prof. Metanis spoke about "Selenium as a Tool for Chemical Synthesis, Modification, and Folding of Proteins." Prof. Uri Banin of the Hebrew University moderated the lecture. Metanis divided his talk into three parts, focusing on the chemistry of selenium and selenocysteine in proteins.

The ICS Awards Ceremony

Prof. Keinan awarded the ICS prizes to all laureates, reading the citations in both Hebrew and English. Representatives of the prize sponsors or the laureate's university joined Keinan for awarding the prize (Figure 5).

Figure 5. Photos from the 2021 ICS Prize Ceremony. First two rows from left: The Excellent Graduate Students prize awarded to Angelica Niazov-Elkan of Weizmann Institute of Science (with Boris Rybtchinski), Efraim Yossef Panfil of The Hebrew University of Jerusalem (with Uri Banin), Dina Rosenberg of Tel Aviv University (with Shmuel Carmeli), Abed Saady of Bar-Ilan University (with Abed's sister, Fatma Saady and David Zitoun), Hadas Shalit-Peleg of Ben-Gurion University of the Negev (with Gonen Ashkenasy), Krishnamoorthy Sathiyan of Ariel University (with Alex Szpilman, and Tomer Zidki), Andrii Varenikov of the Technion (with Mark Gandelman), a joint photo with all seven laureates. Third row: Golik Prize to Yair Segev of the Weizmann Institute (with Yair's Father, Moti Segev, Uri Golik and Moshe Cohen), The 2019 Tenne Prize to Adi Salomon of Bar-Ilan University (with Reshef Tenne), The 2020 Tenne Prize to Fernando Patolsky of Tel Aviv University (with Reshef

Tenne), The Adama Prize to Irit Sagi of the Weizmann Institute (with Itsik Bar-Nahum). Fourth row: the Shahar Prize to Tsipi Maharabani (with Dani Shahar), the Dalia Cheshnovsky Prize to Mirit Kramer (with Dorit Taitelbaum, Ori Cheshnovsky, and Dani Shahar), the Dalia Cheshnovsky Prize to Shulamit Etzioni (with Dorit Taitelbaum, Ori Cheshnovsky, and Dani Shahar), the Itan Peled Prize to Noa Broder (with Michael Peled and Dorit Taitelbaum). Fifth row: the Itan Peled Prize to Gali Inbar (with Prof. Roey Amir, Gali's father, Ran Inbar, Michael Peled and Dorit Taitelbaum), the Green Chemical Industry to Eran Sapir of Veridis Environment (with Gideon Silberman), the ICS Gold Medal to Robert Benny Gerber, Benny Gerber with his son, David Gerber. Sixth row: the ICS Gold Medal to Doron Aurbach, Doron with his wife, Sara Aurbach, the Prize of Excellence to Doron Shabat, and the Young Scientist Prize to Norman Metanis. Last row: the Young Scientist Prize to Menny Shalom, the Honorable Member award to Albert Zilkha, a group photo of Zilkha with his former students (Giora Agam, Galila Agam, Amichai Eisenstadt, David Mirelman, Ben-Ami Feit, Mati Friedkin, and Meir Lahav, Zilkha with his wife Esther, Zilkha with Meir Lahav. Photographs by Itzick Biran.

The 2020 ICS Prizes for an Excellent Graduate Student

Seven graduate students, one from each research university received the award. A representative from every university, either Departmental chairperson or the student's mentor, joined Keinan in awarding the prize.

Angelica Niazov-Elkan (Weizmann Institute of Science) carries out her PhD research with Boris Rybtchinski at the Weizmann Institute. Her work resulted in significant breakthroughs in supramolecular materials, including developing a new class of materials based on molecular organic nanocrystals. These materials are useful as electrodes in solar cells, photonic materials, and fully recyclable separation membranes for water purification. Her achievements offer sustainable alternatives to conventional plastics. Her mentor, Prof. Boris Rybtchinski, joined the ceremony.

Efraim Yossef Panfil (The Hebrew University of Jerusalem), an ultra-Orthodox Jew who grew up in Bnei-Brak and studied in a yeshiva, obtained his BSc from the Jerusalem College of Technology and then joined the group of Uri Banin. His PhD research focuses on coupling effects in colloidal-semiconductor-nanocrystal molecules composed of two core/shell "artificial-atom" building blocks. He achieved optical measurements on individual nanoparticles where coupling effects are otherwise obscured on the ensemble level. His achievements offer potential applications ranging from display devices to quantum information. His mentor, Prof. Uri Banin, joined the ceremony.

Dina Rosenberg (Tel Aviv University) obtained her BSc degree in chemistry (2014) and MSc in physical chemistry (2017) from Tel Aviv University with Yoram Selzer. Her PhD work with Sharly Fleischer focuses on coherent rotational dynamics of molecular ensembles using ultrashort terahertz and near-IR laser pulses. She explores new decay phenomena in coherently rotating gasses. Dina developed a rotational echo spectroscopy methodology and published her achievements in J. Phys. Chem. Lett., Phys. Rev. Lett. and Phys. Rev. Res. Her Department Chair, Prof. Shmuel Carmeli, joined the ceremony.

Abed Saady (Bar-Ilan University) was born in Bu'eine Nujeidat (1992), received his BSc in medicinal chemistry from Bar-Ilan University (with distinction, 2015), and MSc (with honors) with Bilha Fischer. His PhD work with Prof. Fischer focuses on developing novel oligonucleotide probes to detect breast cancer markers. He developed several probes for the detection of target mRNA in total RNA extracted from cancerous cells. He also developed styryl quinolinium dyes that selectively stain ribosomal RNA (rRNA) in nucleoli and mammalian cell cytoplasm. Merck has recently commercialized one of his dyes. His Department Chair-elect, Prof. David Zitoun, joined the ceremony. In his absence, Abed's sister, Fatma Saady, accepted the prize for him.

Hadas Shalit-Peleg (Ben-Gurion University of the Negev) received her BSc (2014) and MSc (2016) from Ben-Gurion University. She carries out her PhD work with Doron Pappo, focusing on oxidative cross-coupling of organic molecules to synthesize versatile target molecules by sustainable and straightforward means. She has expanded the program to achieve enantioselective oxidative coupling reactions, including the enantioselective cross-coupling of phenolic derivatives. She published her work in JACS, Angewandte Chemie, JOC, and Synthesis. Her Department Chair, Prof. Gonen Ashkenasy, joined the ceremony.

Krishnamoorthy Sathiyan (Ariel University) received his BSc in chemistry (2013) and MSc (2015) from the National Institute of Technology at Tiruchirappalli, India, focusing on nanomaterial catalysts for methanol electro-oxidation. In 2016, he started his PhD program at Ariel University with Tomer Zidki and Dan Meyerstein, synthesizing various nanostructured materials and studying their photo- and electrochemical catalytic properties for redox reactions, such as dye-degradation and water-splitting. His Department

Chair-elect, Prof. Alex Szpilman, and Dr. Tomer Zidki joined the ceremony.

Andrii Varenikov (Technion) received his BSc (2012) and MSc in organic chemistry from the Kharkiv National University (2013) with Alexander Roshal. He carries out his PhD research at the Technion with Mark Gandelman, focusing on synthesizing chiral fluorinated organic compounds via nickel-catalyzed cross-coupling reactions. He developed a novel approach to preparing pharmaceutically important chiral ethers, thioethers, alcohols, fluorinated benzhydryls and utilized organotitanium reagents in these transformations. His mentor, Prof. Mark Gandelman, joined the ceremony.

The 2020 ICS - Uri Golik Prize for Excellent Graduate Student

Yair Segev of the Department of Chemical and Biological Physics, the Weizmann Institute of Science, received the award. Dr. Uri Golik and Moshe Cohen joined Keinan in awarding the prize. In his absence, Yair's father, Prof. Moti Segev of the Technion, received the award on his behalf.

The 2019 Tenne Family Prize in Memory of Lea Tenne for Nanoscale Sciences

Prof. Adi Salomon of Bar-Ilan University received the award for her pioneering work on nanoporous metallic networks and the interaction of light with hybrid nanoscale metal-molecule systems. Prof. Reshef Tenne of the Weizmann Institute joined Keinan in awarding the prize. The original plan was to hold this award ceremony during the NANO.IL conference in Jerusalem, in October 2020. Following the cancellation of that meeting, Prof. Salomon received the 2019 Tenne Prize in 2021.

The 2020 Tenne Family Prize in Memory of Lea Tenne for Nanoscale Sciences

Prof. Fernando Patolsky of Tel Aviv University received the award for pioneering the synthesis and assembly of semiconductor nanostructures and applying them to ultrasensitive nanoscale chemical and biochemical sensors. Prof. Reshef Tenne of the Weizmann Institute joined Keinan in awarding the prize.

The 2020 ICS - Adama Prize for Technological Innovation

Prof. Irit Sagi of the Weizmann Institute of Science received the prize for her pioneering research on enzymatic processes using chemical and biophysical approaches and developing inhibitory proteins and antibodies to combat acute and chronic diseases. Dr. Itsik Bar-Nahum of Adama Ltd. joined Keinan in awarding the prize.

The 2020 ICS - Amir Shahar Prize for Excellence in Administrative Management

Ms. Tsipi Maharabani, Director of Administration, Graduate, and International Affairs at the Department of Chemistry at the Ben-Gurion University of the Negev, received the prize for professional and creative management over more than three decades, work ethics, and remarkable human relations with faculty members, administrative staff, graduate students, and postdoctoral fellows. In memory of the late Amir Shahar, the prize was contributed by Bioanalytics Ltd. Amir's brother, Dani Shahar of Bioanalytics Ltd., joined Keinan in awarding the prize.

The 2020 ICS - Dalia Cheshnovsky Prize for Excellence in Chemistry Teaching

Engineer Mirit Kramer of the Ort Kramim high school at Carmiel received the excellent teacher's prize. Prof. Ori Cheshnovsky, Mr. Dani Shahar of Bioanalytics Ltd., and Dr. Dorit Taitelbaum, Chief Inspector for chemistry at the Ministry of Education, joined Keinan in awarding the prize.

Dr. Shulamit Etzioni of the Galim youth village, Kfar Galim, received the Outstanding Young Teacher Prize. Prof. Ori Cheshnovsky, Mr. Dani Shahar of Bioanalytics Ltd., and Dr. Dorit Taitelbaum, joined Keinan in awarding the prize.

The 2020 ICS Itan Peled Prize for Excellent High School Chemistry Project

Noa Broder from the Ilan Ramon High School in Hod Hasharon received the award for her research on the production of atomic chips. She carried out the work in the nanofabrication unit, at the Ben-Gurion University of the Negev, under the supervision of Dr. Erez Golan.

Gali Inbar of the Rotberg School, Ramat Hasharon, received the award for her research work on polymeric micelles as smart drug-transporting vehicles. She performed her research at the School of Chemistry, Tel Aviv University, under Prof. Roey Amir and Mr. Gadi Slor.

The Peled Prize is awarded every year in memory of Itan Peled, who perished in the 1995 Arad disaster. Itan's father, Dr. Michael Peled, and Dr. Dorit Taitelbaum joined Keinan in awarding the prizes.

The 2020 ICS Prize for the Green Chemical Industry

Veridis Environment Ltd. received the prize for applying advanced technologies in recycling municipal and industrial wastes to produce fuels, fertilizers, raw materials, and renewable energy. **Adv. Eran Sapir**, General Manager of the Environmental Services Division, represented the company in the ceremony. Gideon Silberman, a member of the ICS Executive Board, joined Keinan in awarding the prize. The Veridis Group manages waste, water, and energy, thus contributing to the sustainable development of communities and industries. In the last three decades, their waste management division has made remarkable environmental accomplishments as a world leader in the recycling and waste management industry.

The 2020 ICS Gold Medal

Prof. Robert Benny Gerber of the Hebrew University of Jerusalem received the Gold Medal for his fundamental contributions to the structure and dynamics of polyatomic molecular systems and deciphering mechanisms of atmospheric reactions.

Prof. Gerber responded: "I am enormously excited and grateful for this great honor. First, I would like to thank the Israel chemical society and President Ehud Keinan for selecting me. I am very excited about it, and I am grateful to the committee which decided to award me this great honor.

I want to make two comments: first, a dominant fraction of my achievements and recognition belongs to the many brilliant young people who joined me. It was my privilege to supervise these students and postdocs who did the exciting work. I had nearly a hundred students and postdocs, and about thirty of them hold faculty positions in Israel, the United States, and various European and Asian countries. Several of them are now dominant scientific leaders in major fields worldwide. If you ask me what my most important life achievement has been, the raising of these wonderfully creative, stimulating students now making an extraordinary impact on the world scenery. I am very grateful to so many of these people who deserved the credit, and two of them are here with us now.

My second comment is about the leadership of the Israel Chemical Society. I am highly impressed by the tremendous success of the ICS under the presidency of Ehud Keinan over more than a decade. His leadership is dynamic and integrating essentially all aspects of our community, ranging from scientific research superstars to high school students. I am pretty familiar with distinguished chemistry societies, such as the American Chemical Society and the Royal Society of Chemistry, which awarded me various prizes. I should say this: The ICS is one of the most successful chemical societies in terms of momentum and impact at present. I should congratulate the Society and Ehud Keinan. Thank you and thank the ICS for giving a lot of weight to the prize. I am proud to be honored by an outstandingly successful chemical society. Thank you."

Prof. Doron Aurbach of Bar-Ilan University received the Gold Medal for his breakthrough contributions to non-aqueous electrochemistry, developing novel analytical tools, and inventing new rechargeable batteries and electrochemical processes for water treatment.

Prof. Aurbach responded: "First of all, I wish to pay respect to the host institution. We respect the Open University, which offers academic education to many students, providing academic degrees for people who have difficulty achieving the more common route in the other universities. I was privileged to mentor excellent graduate students who came from the Open University. I thank the Open University President, Professor Mimi Ajzenstadt, for making higher education accessible to everyone in this country.

I also wish to thank the Israel Chemical Society. Ehud Keinan, I risk embarrassing you a bit. Still, I must say that I admire your leadership and the way you lead the ICS for many years, faithfully, diligently, and significantly impacting all sectors. You encourage students, young scientists, and established scientists while maintaining your scientific research and publications. So, as a proud ICS member, I take the stage to thank you personally.

I wish to make two personal comments. Rabbi Akiva used to tell his students, referring to his wife: "Yours and mine are all hers." My wife is here with me today. She has been with me all the way, fully supporting my entire career, so everything is hers. I take the opportunity to thank her for so many years of accompaniment. I had to work hard, and she was always at my side, offering her help and support. Thank you, my dear wife.

Prof. Shmaryahu Hoz, my doctoral supervisor, is also here, and I am so happy with his presence. I owe him a great deal. From him, I obtained the scientific basis. We had beautiful years together, and we remained friends in heart and soul. Thank you, Shmaryahu, for your support, friendship, and the fact that we are still very close. Even our labs are close to one another. And I thank you for being a role model scientist, a Professor Emeritus who keeps coming daily to the campus. When I also have become Professor Emeritus, I watch people like you go and contribute from their experience. I think this behavior characterizes the ICS members, as formally retired professors never stop their research. The whole issue of multi-generational continuity is quite common in the Israeli chemical community, making this community so strong.

I feel that the ICS represents an extraordinary, beautiful community. From a broad perspective of several decades in research, I am delighted with my chosen career in chemistry, and the ICS perfectly reflects my point. Chemistry is an interdisciplinary science, widely considered the center of all science. Chemistry produces character and mentality. Our Department of Chemistry at Bar-Ilan University has always been culturally different from neighboring departments, probably because of its interdisciplinary nature. Our research requires collaborations and flow of information, all leading to a character of openness that radiates on the entire Israeli community. The State of Israel is blessed with a glorious community of chemistry far beyond its physical proportions. This community significantly promotes the country.

I wish to say something about chemistry, which is the scientific domain that provides great inspiration. Chemistry allows us to admire Nature. The Lord rules the world using a finite number of laws of Nature, which respond amazingly well to the mathematics that the human brain invented. Nature behaves according to laws that the human brain can grasp, allows for engineering and exploiting Nature's laws to advance humanity and modern life, all inspired by Chemistry. We can watch the most fantastic chemical industry. For example, I work with the vast industry, BASF, a factory the size of Ramat Gan, which produces the best chemical products in the world. Nevertheless, one leaf of grass can do more than the entire BASF in terms of chemical engineering. So, chemistry is a science that inspires and helps to develop the human imagination.

Finally, I am delighted with this recognition. I thank the generations that educated me and the generations that I manage to raise. I feel privileged to now release my 65th PhD. I also had the privilege of having academic children and grandchildren. One of my academic grandsons, Menny Shalom, receives the ICS Award for the Excellent Young Scientist today. As an ICS member, I am happy to be part of a wonderful group of prize winners."

The 2020 ICS Prize of Excellence

Prof. Doron Shabat of the School of Chemistry, Tel Aviv University, received the prize for his seminal contributions to developing highly efficient light-emitting small molecules for signal amplification, drug delivery, sensing, and imaging.

Prof. Shabat responded: "Since you have already heard me talking today, I'll be brief. It is my great honor to receive this award. I wish to share a story related to where I started my career and came to this recognition. More than 30 years ago, I studied at the Technion towards my BSc degree, when Ehud Keinan (Udi) was still a young professor. In those days, and certainly, when I was a high school student, nobody paid attention to the currently recognized problem of attention deficit disorder. Although nobody diagnosed me, I am probably sufficiently intelligent to diagnose myself. I have realized that I suffer from this problem even today. I admit that it is difficult for me to maintain a long conversation for more than five or ten minutes. I immediately lose attention, and my thoughts wander to other places.

Nevertheless, I completed my BSc degree as an average student, or perhaps even below average. My career started taking off only when I stepped into the research lab and carried out my research program with passion and dedication, and my success drove me forward. But nobody mentioned my limitations, including Udi, who was my first mentor. I think that if he would disagree with me, he is just trying to be polite. Those days, nobody could predict that I'll become a university professor one day, certainly not a laureate of the ICS Prize of Excellence. At least, I can attest to myself that my driving forces were my passion, imagination, and creativity. These elements are the essential keys to success in any academic career. Shmuel Carmeli, the current Head of the School of Chemistry in Tel Aviv University, is here today, would agree with me. When I first interviewed for a position in the School of Chemistry, I could not announce that I was not the sharpest pencil in the pencil case, a reason to receive some discount. Nevertheless, today I ask my colleagues for exemption from various administrative responsibilities, and they understand.

So, I want to take this opportunity to thank once again my teachers, my doctoral supervisor who is here, and of course, the fantastic group of students I had over the years. I like the cliché that a person learns much from his teachers, but even more from his students. It represents me perfectly well. My outstanding students are fully responsible for the reason I am here today. One of them, Prof. Roey Amir, winner of the 2018 ICS Excellent Young Scientist Prize, is here with us today. Thank you all very much for your attention."

The 2020 ICS Excellent Young Scientist Prize

Prof. Norman Metanis of the Hebrew University of Jerusalem received the prize for his contributions to the chemoselective synthesis of therapeutic proteins, and to the understanding of the function of human selenoproteins.

Prof. Metanis responded: "I want to begin by thanking the award committee for selecting me for this award. I am truly honored to receive this important recognition. It is an even more tremendous honor to be placed in such distinguished ranks as past awardees, many of whom are colleagues and close friends.

First and foremost, I thank my family for their vast support, my wife Johaina, and kids Emil, Stephan, and Liam. Being in academia is challenging. It means working seven days a week and for extended times. So, I thank you, my dear, for your love and understanding.

Of course, I want to thank my mom Mimi, brothers Jack and Issa, and sister Joyce for their eternal love and support. And I want to dedicate this award to my father, who worked as a mathematics teacher for over 33 years and died 3.5 years ago after a long battle against ALS.

I was raised in Maghar, in Galilee, to a family that values education. Both my parents were teachers. And being the eldest came with a lot of responsibility. My parents told me multiple times, “If you do not get educated, none of your siblings will get educated.” So, it was a lot to carry, but happily, my siblings are well educated. Jack is a successful lawyer, Issa is a senior doctor of neurology, and Joyce is a pharmacist.

In the Arab society, many parents, including mine, encourage their kids to pursue a medical doctor career. For that reason, we see so many Arab doctors these days. I remember that, as little boys, before my sister was born, my mom used to call us from the kitchen in Hebrew: “Dr. Norman, Dr. Jack, Dr. Issa, please go to the operation room. And if you are hungry, please come to the kitchen.”

So, I wanted to be a medical doctor because I did not know what else would fit me, and I never met a scientist or professor in my life. Fortunately, I was not accepted to the medical school because I didn’t do so well on the psychometric exam, specifically in the English section. Since I liked chemistry at school, I decided to study chemistry at the Technion. I am sure you know that it is tough to study at the Technion, yet I got the highest recognition of excellence in the first year, far more important than the actual grades. I fell in love with chemistry, and then I knew that my destination was to be a scientist rather than a medical doctor. I worked hard to achieve my new goal of becoming a professor of chemistry. In fact, while still a second-year undergraduate student, I started working in Udi’s lab. I remember that Udi was very open, and he asked me, “What do you want to be?” and I answered, “I want to be like you.” I wish to thank everyone who helped me accomplish my goal, primarily my PhD supervisor, Udi Keinan, my second advisor, Phil Dawson, and my postdoc supervisor Don Hilvert. I learned a lot from each one of them, and their guidance helped shape the scientist that I am today.

Any accomplishment for which I receive this award is due to my students’ persistence and hard work, and I thank them from the bottom of my heart. I only came up with the ideas, but they have done the actual work.

Finally, the Arab society has made outstanding accomplishments through higher education in the last two decades. I am sure we will continue to reach milestones and close the gaps between the different segments of Israeli society. In my talks at Arab schools, I meet many excellent students, and I encourage them to choose the career that suits them most, love it, and work hard to achieve their goals. Thank you all for your kind attention.”

Prof. Menny Shalom of the Ben-Gurion University of the Negev received the prize for developing carbon nitride-like materials for photo-electrochemical cells with energy-related applications.

Prof. Shalom responded: “Thank you very much. Considering the late hour, I promise to be brief. Also, my wife has just sent me a note that my children are waiting for me before going to bed. Many thanks to the Israel Chemical Society for the honor. I’m proud to be a member of this active society. I thank my PhD supervisor Prof. Arie Zaban and the glorious academic tree from which he descended. I thank my postdoctoral mentor, Prof. Markus Antonietti of the Max-Planck Institute of Colloids and Interfaces. Special thanks go to Ben-Gurion University and the Department of Chemistry for giving me the opportunity and tools to build my group and accomplish my research program. I am very thankful to my excellent group members and collaborators over the years. Above all, I thank my parents for insisting on a good education as their top priority, even in difficult times. Education has always been essential to them. I thank my wife and kids for all the support, love, and help over the years. Finally, I thank you all for staying with me until the end of this ceremony.”

The 2020 Honorable Member of the ICS

Prof. Albert Zilkha of the Hebrew University of Jerusalem received the award for his seminal contributions to polymer chemistry, achievements in chemistry teaching, and service as a role-model mentor of young chemists. The award ceremony took place on June 16 in the Mishkan Shmuel synagogue at Giv’at Mordechai in Jerusalem, attended by his family and many of his former students.

Prof. Zilkha responded: “Hello everyone and thank you very much for coming. I want to thank the ICS, and President Professor Ehud Keinan, for awarding me the Honorable Membership. I also wanted to thank those who have recommended me for this award, primarily Professor Meir

Lahav, who worked hard for this recognition without my knowledge.

I oversaw the organic chemistry laboratory at the Hebrew University, so many students who took that lab wanted to join my research group. It was crucial for me that they succeed, and indeed, every one of them published at least one research paper with me. Some of these students completed their doctoral work with me. Others took my recommendation to do their PhD at the Weizmann Institute or in other universities. I was happy to see that most students who completed their PhD in my lab later developed successful careers.

My research focused on polymer science, which was underdeveloped those days. To benefit my graduate students, I constantly launched new projects and entered new fields, and every successful topic opened the way to additional issues. In recent years, I have written several books, specifically in Hebrew, to help young students.

I thank all my former students, research associates, and all colleagues in research and teaching laboratories. I wish you all continuing success in everything you are doing. And finally, I want to bless you all with the Priestly Blessing: 'May God bless you, and guard you. May God make His face shine unto you and be gracious to you. May God lift His face unto you and give you peace.' "

Closing remarks

Ehud Keinan closed the event: "I wish to respond to the warm compliments offered by the gold medalists Benny Gerber and Doron Aurbach, and I want to make three comments. First, nobody can argue that the ICS is a globally visible and highly influential society worldwide. People can offer different reasons for this observation. In my view, a dominant key to the success story of the ICS and the entire Israeli scientific community is our unique culture. People care about one another, tending to cooperate, collaborate, and exchange ideas. Most Israeli scientists are happy with the achievements of their colleagues rather than being jealous of them. Of course, as is the case worldwide, there are competition and internal politics, but we still behave like members of a big family. Based on my experience, I can testify that these characteristics are less common in other cultures and countries. This behavior is probably the main reason that the ICS has been so successful over nearly a century.

My second comment relates to Norman's story that, as a young student, he wanted to be like me. It reminds me of a true story about the famous composer George Gershwin, who approached the accomplished composer, Arnold Schoenberg, requesting to become his student in private composition lessons. When Schoenberg asked him to explain his goals, Gershwin answered, "I wish to become the second Arnold Schoenberg." Schoenberg responded angrily, "Why do you want to become Schoenberg number two if you can be Gershwin number one?" I recommend all young students to remember this story.

The third comment relates to the presumably suspicious observation that a high proportion of ICS prize winners started their careers in my research group. With some sense of humor, I could argue that there is evidence of institutional corruption at the ICS. Nevertheless, you should know that entirely independent juries select all prize winners, and I am not part of their decisions. The jury members, who serve for three years, make highly successful decisions because they all maintain strict independence and confidentiality. I consider myself very lucky to have so many excellent students over the years. I am happy watching them develop bright careers either in the academic world or in the chemical industry.

Finally, I thank all prize winners, students, friends, and families for attending this exciting event. I must admit that I am emotional and moved by ICS prize ceremonies. For me, awarding the ICS prizes has always been the most rewarding part of my highly demanding responsibility as ICS President for more than 13 years. I hope to see you again at the 86th Annual Meeting of the ICS on February 22–23, 2022. Thank you all for coming and for actively contributing to this successful Prize Ceremony."

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