INTERNATIONAL SOL-GEL SOCIETY

ISGS

materials through chemistry

eMarathon

10 December 2024

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On 10th December, 2024, the ISGS will launch a new initiative, the Sol-Gel Early-Career-Researcher eMarathon. The eMarathon will involve a series of lectures by early-career researchers (ECRs), with each lecture being of 30 minutes duration with an additional 10 minutes for questions. Our goal is to showcase the depth and diversity of the sol-gel research being undertaken by our ECRs and to provide an opportunity for them to present their work to an international audience in a relaxed, online forum.

We look forward to your participation in the inaugural ECR eMarathon and to your support of our ECRs, the future leaders of the sol-gel community of practice.

Date: **Tuesday 10 December 2024**

Time:

07:00 - USA (East Coast)	09:00 - Chile, Argentina and Brazil (São Paulo)
12:00 - UTC	12:00 - UK, Portugal
13:00 - Switzerland, Central Europe, Sweden	14:00 - Romania, Israel, Eastern Europe, Ukraine
13:00 - Russia (Moscow, St Petersburg)	20:00 - China, Singapore, Malaysia
21:00 - Japan, Korea	22:00 - Australia (Queensland)

ZOOM: https://us02web.zoom.us/j/3072916432?pwd=nENym8GN1X5X9uAZrLNsA3uhLChiae.1&omn=84749317162

Meeting ID: 307 291 6432
Passcode: #dr0m2Kq7X

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Program

Speaker	UTC	Europe Time	Brazil/ Argentina Time	Australia (Victoria) Time
John Bartlett (Opening Comments)	12:00 – 12:05	13:00 – 13:05	09:00 – 09:05	23:00 - 23:05
Maria Basso *(Industrial Engineering Department, University of Padua, Italy)* **Pulsed-laser annealed amorphous/ crystalline *a*-V_2O_5/VO_2 heterostructures for selective NO_2 and H_2 sensing**	12:05 – 12:45	13:05 – 13:45	09:05 – 09:45	23:05 - 23:45
Kamal Mohamed Seeni Meera *(Institute of Materials Research German Aerospace Center (DLR), Cologne, Germany)* **Carbon Aerogel Beads: Preparation, Characterization and Upscaling**	12:45 – 13:25	13:45 – 14:25	09:45 – 10:25	23:45 - 00:25
Ani Vardanyan *(Department of Molecular Sciences, Swedish University of Agricultural Sciences, Sweden)* **Green Chemistry Meets Sol-Gel: Designing Functional Materials for Environmental Applications**	13:25 – 14:05	14:25 – 15:05	10:25 – 11:05	00:25 - 01:05
Coffee Break	**14:05 – 14:30**	**15:05 – 15:30**	**11:05 – 11:30**	**01:05 - 01:30**
Francisco Navas *(Chemical and Environmental Engineering, Rey Juan Carols University, Madrid, Spain)* **Mesoporous organosilica nanomedicines as drug delivery systems of Pt(IV) and Sn(IV) prodrug antitumor complexes**	14:30 – 15:10	15:30 – 16:10	11:30 – 12:10	01:30 - 02:10
Roberta Pugina *(São Paulo State University (UNESP), Institute of Chemistry, Araraquara, São Paulo, Brazil)* **Photonic devices with controlled circularly polarized light emission**	15:10 – 15:50	16:10 – 16:50	12:10 – 12:50	02:10 - 02:50

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Pulsed-laser annealed amorphous/crystalline *a*-V_2O_5/VO_2 heterostructures for selective NO_2 and H_2 sensing

Maria Basso[1], Valentina Paolucci[2], Vittorio Ricci[2], Elena Colusso[1], Mattia Cattelan[3], Enrico Napolitani[4], Carlo Cantalini[2], and Alessandro Martucci[1]

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Abstract

Gas sensors play a crucial role in multiple applications, including environmental monitoring, industrial safety, and medical diagnostics, due to their ability to detect harmful gases such as nitrogen dioxide (NO_2) and hydrogen (H_2). A selective and timely detection of these gases is challenging, yet essential.

Semiconductor metal oxides have emerged as promising sensing materials due to their chemical stability, surface activity, and tunable electronic properties, making them highly responsive to target gases under various environmental conditions. Amorphous/crystalline metal oxide heterostructures constitute a new class of gas sensing materials, offering high concentrations of adsorption sites within the amorphous phase and the presence of amorphous/crystalline heterojunctions.

In this talk, I will report on amorphous/crystalline V_2O_5/VO_2 heterostructures, synthesized by coupling a sol-gel process with pulsed laser annealing. This technique allows for simple and ultrafast annealing of the irradiated material, remarkably lowering the energy consumption related to the fabrication process.

The sensors demonstrated selective responses to NO_2 and H_2 under different conditions. In the absence of platinum (Pt) decoration, the sensor exhibited strong selectivity toward NO_2, with a detection limit as low as 400 ppb. Upon decorating the *a*-V_2O_5/VO_2 surface with Pt nanoparticles, the sensor's response showed selectivity towards H_2, with detection limit down to 5 ppm. Low operating temperatures could be achieved, enhancing the energy-efficiency with respect to conventional high-temperature metal oxide sensors. Additionally, the gas sensing mechanism of the *a*-V_2O_5/VO_2 heterostructures will be discussed.

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Carbon Aerogel Beads: Preparation, Characterization and Upscaling

Seeni Meera Kamal Mohamed

Institute of Materials Research, German Aerospace Center (DLR), Cologne, Germany.

Abstract

In the last several years, there has been an increased interest among researchers in the development of carbon based materials such as activated carbon, carbon beads (micro- and milli-meter sized) and microspheres, carbon nanotubes, graphene, fullerene, etc. Carbon based materials exhibit unique structures, morphologies, properties and so on. Among these materials, carbon aerogels (CAs) are extraordinary materials with high surface area, high porosity with unique micro-structures consisting of micro-pores, etc. CAs find applications in catalysis, chromatography, energy, adsorbents, desalination, etc. Currently, researchers are focused on the development of CAs in the form of spheres and beads instead of monoliths due to the reduction in processing time and equipment costs.

Carbon beads (CBs) are produced conventionally from coal or petroleum pitch by carbonizing them at 350-500 °C to achieve mesophase spheres in pitch. The carbonization process is quenched before extensive growth and aggregation of the spheres occurs, and the CBs are separated as solids from soluble pitch by extraction with a solvent. Carbon microspheres of 1 mm to 3 mm are also fabricated by using an inverse-emulsion gelation of resorcinol-formaldehyde (RF) solution at high temperatures followed by super-critical drying and subsequent carbonization. The removal of oil and subsequent super-critical drying consume large amount of solvents, energy and time. Hence, there is an increasing demand for an easy process to form CBs.

In the current work, we utilized sol-gel chemistry to form RF aerogel beads after ambient pressure drying and converted them using a thermal treatment process into carbon beads. The existing challenge is the shaping of RF sol into beads by a dropping method, which has not been previously reported in the literature because of the low sol viscosity (~ 0.5 Pa.s). Hence, we adjusted the viscosity of the RF sol by adding a polysaccharide-based thickener to achieve RF bead formation (1-10 Pa.s), followed by sub-critical drying and carbonization. The average sizes of the carbon beads are in the range of 1.75-2.02 mm with skeletal densities of 2.0-2.4 g/cm^3. The micropore surface area and pore volume are ranging from 735-901 m^2/g and 0.28-0.35 cm^3/g, respectively. SEM images reveal that the beads are spherical with an inner-morphology composed of inter-connected particles grown on the top of the thickening agents' fibers.

The large scale production of RF aerogel beads by a Jet-Cutting method has several challenges *viz.,* handling of enormous amounts of RF sol and acid bath, process parameter optimization, waste disposal, etc. Hence, we adopted low to high viscous alginate solution (0.5 - 3wt.%) with a viscosity ranging from 0.08 to 10 Pa.s, as a model system to optimize the Jet-Cutting parameters. The diameter of the beads (d_{bead}) is described by:

$$d_{bead} = \sqrt[3]{\frac{3}{2} D^2 \left(\frac{u_{fluid}}{n.Z} - d_{wire}\right)}$$

where D is the diameter of the nozzle; u_{fluid} the fluid velocity; n the number of cutting wires; Z the number of cutting tool rotations; and d_{wire} *the diameter* of the wire.

The impact of key process parameters, including the fluid velocity, diameter of the nozzle and number of cutting tool rotations were explored and optimized, leading to the large scale production of RF beads. The properties of the beads will be described.

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Green Chemistry Meets Sol-Gel: Designing Functional Materials for Environmental Applications

Ani Vardanyan

Department of Molecular Sciences, Swedish University of Agricultural Sciences, Sweden

Abstract

With increasing industrialization and population growth, the demand on global freshwater resources continues to escalate, requiring efficient and environmentally sustainable water treatment solutions. Traditional methods of water purification, while effective, often rely on different processes that can generate secondary pollutants and contribute to environmental pollution. In response, green chemistry offers a transformative approach, aiming to minimize the ecological impact of treatment processes while promoting renewable and safe materials. This talk presents research at the intersection of green chemistry and sol-gel technology, focused on developing advanced materials for sustainable water purification.

Different approaches were designed in our group utilizing both nanomaterials and natural silicates, to remove inorganic and organic pollutants. Through the application of sol-gel chemistry, we have created robust and reusable materials capable of encapsulating biological molecules, such as enzymes, within protective silica shells, enhancing both their stability and effectiveness. These materials offer a scalable, eco-friendly solution for water purification, aligning with green chemistry principles by reducing waste, improving recyclability, and lowering energy demands. This presentation will cover the synthesis and characterization of these advanced materials, highlighting their potential to meet current and future demands for clean water.

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Mesoporous organosilica nanomedicines as drug delivery systems of Pt(IV) and Sn(IV) prodrug antitumor complexes

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Abstract

Currently, three Pt(II) compounds - cisplatin, carboplatin, and oxaliplatin - are widely employed in cancer chemotherapy against different types of tumour malignancies. However, they present severe patient side-effects, such as ototoxicity, nephrotoxicity, hepatotoxicity, gastrointestinal disorders, hair loss or anemia. Moreover, these complexes suffer inactivation in the organism after parenteral administration because of secondary reactions with different biomolecules in the human body, considerably decreasing the amount of unaltered complex that reaches the biological target. To overcome these limitations, in the last decades, research on Pt(IV) prodrugs has identified a promising area in the development of new derivatives, with different physico-chemical properties compared with their conventional Pt(II) counterparts. However, some of these Pt(IV) complexes have been discarded from clinical use because of their side-effects.

Apart from that, most tumor cells generate mechanisms of resistance against platinum drugs in long-term treatments, which has led to an intensive search for new metal-based drugs that can overcome this limitation. In this context, Sn-based compounds have shown promise due to their pharmacological properties and lower toxicity levels in different cancer cells lines, both *in vitro* and *in vivo*, in addition to overcoming Multi-Drug Resistance (MDR) . In order to i) avoid the inactivation of metallodrugs by the organism, ii) reduce the dose administered to the patient and; iii) improve their cellular uptake, the use of mesoporous silica nanoparticles (MSNs) offers the possibility of having an efficient and selective drug-delivery system, in addition to good biocompatibility and bioaccumulation. MSNs present particular features that make them excellent candidates for biomedical applications.

In this talk, we present a pioneering method for drug integration into nanoparticles known as mesoporous organosilica drugs (MODs), a distinctive variant of periodic mesoporous organosilica (PMOs) nanoparticles. In these MODs, the metallo-prodrug is an inherent component of the silica nanoparticle structure. This groundbreaking approach involves the chemical modification of metal drugs to produce bis-organosilane-based metal prodrugs, which act as silica precursors for MOD synthesis via a sol-gel method. Two different approaches are presented using metallic MODs of Pt(IV) and Sn(IV) prodrugs (Pt(IV)@MODS and Sn(IV)@MODs). These metallodrugs with bis-organosilane ligands have been incorporated within the silica structure of the nanoparticle via covalent binding from a polymerization process in a one-step reaction. The selected Pt(IV) prodrug had already showed very promising results in terms of cytotoxic activity both *in vitro* and *in vivo* in colorectal cancer cells, presenting higher activity than cisplatin, in addition to a lower selectivity against the healthy intestinal ones.

The synthesized metallic MODs have been characterized by the usual techniques and subsequently tested for their viability as drug-delivery systems. Biodegradation studies have been also performed to determine the degree of degradation in different media and to quantify the release of the metallo-prodrug from the nanoparticles. In the case of Pt(IV)@MODs, magnetic (Fe_3O_4) nanoparticles were incorporated, generating magnetic Fe_3O_4@MODs to actively target the tumor and further enhance drug efficacy. Studies of the antiproliferative activity *in vitro* have been carried out with both types of metallic MODs different cancer cell lines, obtaining very promising results. In addition, in the case of the Sn(IV)@MODs, their capacity to overcome MDR has also been evaluated .

The MOD based-Pt nanomedicines have demonstrated their efficacy in significantly reducing the viability of colorectal cancer cells, particularly in the case of Pt(IV)-Fe_3O_4@MODs. Moreover, confocal studies showed the internalization of these materials by the tumor cells. It is important to note that there seems to be a synergistic action between the platinum and the magnetite that improves the pharmacological action of the Pt(IV)-Fe_3O_4@MODs against the tumor cells.

Finally, *in vivo* studies carried out in mice inoculated with the colorectal cells with the Pt(IV)@MODs showed that the nanoparticles reduced tumor growth similarly to the free bis-organosilane Pt(IV) compound, with reduced side-effects.

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Photonic devices with controlled circularly polarized light emission

Roberta Pugina

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Abstract

Photonics rapidly evolved following the development of the first laser in the early 1960s [1]. Since then, this research field has utilized photons to perform functions traditionally associated with electronics, such as telecommunications and information processing. Alongside advancements in photonics, optical devices have been engineered from materials with tunable chemical and physical properties, enabling the creation of specialized sensors, lasers, and waveguides with unique functionalities [2]. Often, these functionalities can be achieved by modifying the shape and/or structure of well-known materials. In the context of random laser (RL) emission [3], plasmonic nanoparticles have already been explored as a scattering medium, as the surface properties of these materials can enhance random laser emission through the electric field and scattering they generate [4,5]. However, there is still much to be explored with chiral systems, which can promote emission with circular polarization (CP). To develop RL-emitting devices with CP control, for instance, chiral metallic nanoparticles with strong circular dichroism [5] can be used in suspension or incorporated in solid films. Additionally, to achieve CP emission, materials with liquid crystal behavior, such as cellulose nanocrystals, can be employed to create systems organized in chiral nematic structures [6,7]. Given this, the current work will present recent examples of research on photonic devices based on luminescent materials, including inorganic particles and natural polymer films, as well as ongoing research focused on developing chiral films for photonic devices that aim to achieve CP emissions. The results of these studies highlight the growing potential for tailored photonic applications by exploiting the unique optical properties of chiral and liquid crystalline materials. This approach not only broadens the functional capabilities of photonic devices but also paves the way for advancements in fields such as optical sensing, quantum computing, and advanced telecommunications. By leveraging these material properties, it is possible to design devices with greater control over light polarization, which could be critical for developing next-generation photonic technologies.

References

1. Maiman, T. H. *Nature*, 187 (1960); **2.** Saleh, B. E. A. & Teich, M. C. *John Wiley & Sons* (2019); **3.** Lawandy, N. M. et al. *Nature*, 368 (1994); **4.** Ning, S. et al. *Opt Lett*, 40 (2015); **5.** Lee, S. et al. *ACS Phot*, 9 (2022); **6.** Fernandes, S. N. et al. *Curr Opin Solid State Mater Sci*, 23 (2019); 7. Zhang, X. et al. *Light Sci Appl*, 11 (2022).

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