



## Workshop report: Advanced carbon materials for energy storage applications

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## Background

The workshop on Advanced Carbon Materials for Energy Storage, co-organized by Polymeris and Aramco, aimed to explore the latest technological developments and foster collaboration in the field of carbon-based materials such as graphene, graphite, and carbon nanotubes. This initiative is part of a broader partnership between Polymeris and Aramco to accelerate innovation in strategic sectors including energy, mobility, and sustainable materials.

Focusing on the role of advanced carbon materials in next-generation energy storage systems, the event brought together leading companies and research organizations to share insights on market trends, emerging technologies, and industrial challenges.

The objective was to identify synergies, stimulate joint R&D opportunities, and lay the groundwork for future partnerships aligned with Aramco's innovation priorities and sustainability goals. Through targeted discussions and technical presentations, the workshop served as a platform to accelerate the adoption of high-performance carbon solutions in energy storage applications.

## Workshop Overview

### Opening Remarks and Introduction

Samir Zaky (Polymeris) opened the session by highlighting the importance of building strong collaborations around advanced carbon materials for energy storage applications. He underlined that this workshop marks a second step in a broader initiative launched with Aramco to explore the potential of non-metallic and carbon-based materials across key sectors. Following the first session dedicated to construction, this second workshop focuses on graphene, graphite, and carbon nanotubes for energy storage, particularly in electric mobility. Future workshops will continue to explore other strategic applications, with the goal of establishing a dedicated working group and fostering long-term R&D partnerships.

## Summary of Presentations

### Frost&Sullivan – Abhishek Paul Choudhury

Abhishek presented key trends shaping the future of advanced carbon materials in energy storage, particularly for electric vehicle batteries. He highlighted strong market growth driven by the rising demand for high-performance batteries, falling production costs, and supportive government policies. Emerging technologies include graphene-based anode replacements, CNTs for improved battery life, and sustainable synthesis methods using renewable or waste resources.

A patent and publication analysis showed intense activity around CNTs and graphene, particularly in Asia-Pacific, with leading contributions from tech firms and universities. However, a notable gap remains in patents addressing the recycling of these materials.

Looking ahead, Abhishek emphasized the shift toward hybrid nanostructures, sustainable and scalable production, and AI-driven materials optimization as critical areas for innovation and industrial impact.

### **Saudi Aramco – Nada Qari**

Aramco presented its R&D strategy centered on the development and industrial deployment of advanced carbon materials. A key highlight was the creation of a Center for Carbon Materials, a first-of-its-kind facility in the region, established in collaboration with King Fahd University of Petroleum & Minerals (KFUPM). This center aims to drive technology localization, sustainable material innovation, and knowledge transfer.

The center will focus on the development of high-performance carbon materials such as carbon fiber, graphene, nanocarbons, and synthetic graphite, with targeted applications in energy storage systems, wind energy, and hydrogen technologies. Aramco emphasized the strategic importance of these materials in enabling next-generation energy solutions and reducing the environmental footprint of industrial sectors. The center is expected to become fully operational by 2028 and will serve as a regional and international hub for carbon materials innovation.

### **Chalmers University – Jinhua Sun**

Professor Jinhua Sun presented a comprehensive overview of his group's research on graphene functionalization and composites, highlighting their wide-ranging applications in energy storage, including lithium-ion, sodium-ion, and lithium-sulfur batteries, as well as supercapacitors.

He discussed the surface functionalization of graphene to tailor interlayer distance, surface chemistry, and structural properties, enabling the design of high-performance composite electrodes. One of the key innovations presented was the development of "Janus graphene", an asymmetrically functionalized material specifically engineered for sodium-ion batteries, which offers both enhanced intercalation capabilities and the potential for scalable synthesis.

Professor Sun also introduced pillarized graphene structures and covalent organic frameworks (COFs) as promising candidates for high surface area electrodes, particularly relevant for hydrogen storage and supercapacitor applications. The use of graphene coatings to enhance the electrochemical stability of silicon anodes was also explored, addressing challenges such as volume expansion and cycling degradation in lithium-ion batteries.

In the context of lithium-sulfur batteries, he presented strategies involving functionalized graphene to mitigate the polysulfide shuttle effect, thereby improving sulfur utilization, energy density, and cycling stability. Additionally, Professor Sun showcased various graphene-metal and graphene-polymer composites, demonstrating their potential in 3D printing, anti-corrosion coatings, EMI shielding, thermal management, and tribological applications.

### **Versarien/ Gnanomat – Steve Hodge/ Roberto Clemente**

Versarien presented its NanoCaps technology, a hybrid nanomaterial platform that combines graphene, activated carbons, and nanoparticles to enhance electrode performance in energy storage systems. The technology delivers both high power and energy density, with a focus on safety, sustainability, and adaptability for various applications such as off-road vehicles (ATVs), aerospace, and renewable energy systems.

The company emphasized the modular and customizable nature of their materials platform, designed to meet specific industrial performance needs while maintaining eco-friendly production processes.

### **Graphmatech – Alexis Montoya**

Graphmatech presented its work on scaling up graphene-polymer composites for industrial applications. The company showcased its patented technology that optimizes graphene dispersion within various polymers, enabling standard industrial processing like extrusion, injection molding, and blow-molding.

Graphmatech emphasized its role as a technology partner, offering masterbatches, compounds, and co-development roadmaps with industrial clients. The company supports the full value chain, from formulation and processing to performance testing and market integration.

### **PSI – Banerjee Sarbajit & Mario El Kazzi**

PSI researchers presented their work on advanced battery research, with a particular focus on converting fossil fuel-derived feedstocks—including bitumen, asphaltenes, and sulfur by-products—into battery-grade carbon materials. Their objective is to develop sustainable, high-performance electrodes for next-generation energy storage technologies, covering lithium-ion, lithium-sulfur, sodium-ion, and solid-state batteries.

They detailed the development of structured and porous carbon materials from heavy fossil fractions using patented processes, as well as the design of graphite/silicon composite anodes, carbon hosts for lithium-sulfur and sodium-sulfur systems, and solid-state Li-S batteries based on feedstocks supplied by Aramco. The team highlighted their deep expertise in understanding battery mechanisms, degradation, and aging, supported by advanced

characterization techniques such as synchrotron XAS, OEMS, Raman spectroscopy, and operando XRD.

PSI also outlined a collaboration roadmap, which includes proof-of-concept studies, pouch cell demonstrators, the exchange of visiting scientists, and potential joint ventures. They emphasized their ability to support the entire battery development cycle, from materials discovery through to pilot-scale validation, and underscored the strategic importance of partnering with Aramco to scale up carbon-based technologies derived from fossil resources.

### **Carbon Waters – Charlotte Gallois**

Carbon Waters presented its graphene-based additives developed to enhance the performance and reduce the environmental impact of composite materials. Thanks to a patented liquid-phase process, the company produces high-quality graphene dispersions that are directly compatible with industrial formulations and processing techniques.

During the presentation, they introduced two main additives. The first, GraphUp, allows manufacturers to optimize curing cycles by significantly reducing curing time and energy use. The second, Graphene Force, improves the mechanical properties of resins, enabling the design of lighter and more robust composite parts—particularly relevant for applications such as tanks and pipes.

Carbon Waters emphasized its collaborative approach, working together with industrial partners to adapt and integrate these additives into specific manufacturing workflows, aiming to deliver both performance gains and environmental benefits.

### **Horiba – Ludivine FROMENTOUX**

HORIBA presented its wide-ranging capabilities in the characterization of advanced carbon materials, offering solutions from laboratory-scale R&D to fully integrated process control. With over 200 years of expertise in optics and spectroscopy, and a global presence across R&D centers and manufacturing sites, HORIBA positions itself as a key partner for the battery and hydrogen sectors. The presentation highlighted HORIBA's comprehensive portfolio of instruments and integrated solutions tailored to energy applications, including lithium-ion, sodium-ion, and supercapacitors, as well as fuel cells and electrolyzers. Special emphasis was placed on carbon material characterization, such as measuring crystallinity (ID/IG ratio), elemental impurities, particle properties, and conductive agent content, all of which are critical for optimizing energy and power density in devices.

Using tools like Raman spectroscopy, AFM, and elemental analysis, HORIBA enables accurate, automated, and scalable assessments of carbon-based materials like graphene, GO, and rGO, helping manufacturers better control performance, stability, and durability. The company also demonstrated automated software workflows, customizable data reports, and end-to-end

integration into production environments, reinforcing its commitment to advancing material science for the energy transition.

### **Nawah – Alain Guinot**

Nawah Technologies presented its vertically aligned carbon nanotube (VACNT) technology, emphasizing the uniqueness of its production process and its ability to manufacture these materials at industrial scale. The presentation focused on evaluating the potential of VACNTs to enhance the performance of composite materials and their relevance for industrial applications.

The company highlighted the versatility of its VACNTs, which can be transferred onto various substrates and functionalized with different materials. They showcased several use cases, including improved fatigue resistance in composites, enhanced hydrogen permeability control, and the development of advanced electrodes for fuel cells and electrolyzers. Nawah underlined the maturity of its technology and its ability to adapt to specific industrial requirements.

### **BeDimensional – Francesco Bonaccorso**

BeDimensional presented its capabilities in producing high-quality two-dimensional materials, specifically graphene and hexagonal boron nitride (h-BN), at industrial scale. The presentation focused on the relevance of these materials for advanced applications in energy storage and conversion, and their potential integration into future projects.

The company highlighted ongoing collaborations with industrial partners and research institutions, as well as its participation in several European and international R&D projects. Key applications discussed included lithium-ion batteries, perovskite solar cells, and water-splitting technologies, where BeDimensional's materials have shown promising effects on performance and long-term stability.

The discussion confirmed the maturity of their production platform and opened the door for further exploration of these materials' suitability for specific industrial needs. Continued engagement with BeDimensional to assess the compatibility and added value of their materials was identified as a key next step.

### **LSE – Norbert Schramm**

LSE presented its innovative hydrogen storage pressure vessel design, developed to outperform current market solutions in terms of weight, capacity, and production efficiency. Their new vessel architecture achieves a 31% reduction in system mass and a 30% increase in hydrogen storage capacity, thanks to a unique non-cylindrical geometry and optimized material usage.



The company also showcased its fully automated manufacturing process, based on a proprietary ring-winding machine, which enables faster and scalable production. Norbert Schramm highlighted the role of Taupreg, LSE's dry pre-impregnated composite material, which reduces processing time by approximately 30% compared to traditional wet winding. He also discussed joint developments with Fraunhofer IWU, aimed at improving their carbon fiber reinforced materials using carbon nanotubes.

LSE confirmed that market entry is approaching and shared plans to expand toward larger vessel formats for high-capacity applications, including forestry and heavy-duty vehicles.

### **Graphenea – Amaya Ortega**

Graphenea presented its expertise in the development and commercialization of graphene oxide-based additives for a wide range of industrial applications, with a particular focus on energy storage and materials enhancement. The company emphasized its ability to deliver cost-effective and environmentally friendly solutions to improve performance across sectors such as construction, packaging, and hydrogen technologies.

In the construction field, they showcased a concrete additive that reduces oxygen permeability by 95% and extends service life by 50%. For the packaging industry, their additive improves the drying rate of adhesives, enabling faster production speeds and reducing both waste and energy consumption.

In energy-related applications, Graphenea detailed its involvement in European R&D projects targeting hydrogen storage tanks and water electrolysis membranes. They are developing graphene oxide derivatives for enhanced hydrogen absorption and exploring graphene aerogels to improve electrocatalytic performance.

The presentation highlighted the company's strong commitment to sustainability, innovation, and the scalable industrial application of graphene materials.

### **Grafintec – Rasmus Blomqvist**

Grafintec presented its plans to develop a coated spherical graphite production facility in Finland, positioning itself as a key player in the European battery anode supply chain. The company emphasized the importance of localizing graphite processing in Europe to reduce dependency on imported materials and meet growing demand from the electric vehicle sector. Rasmus Lundqvist outlined Grafintec's strategy to produce battery-grade graphite using a caustic baking purification process, which is more environmentally friendly and cost-effective than traditional hydrofluoric acid-based methods. This process aligns with EU sustainability goals and strengthens Europe's ability to meet its critical raw materials targets.

The presentation included projections for production capacity, economic performance, and the timeline toward full-scale operation. Grafintec also highlighted its pursuit of EU funding

and strategic partnerships to accelerate the deployment of its project and support Europe's transition to a secure and sustainable battery ecosystem.

### **Talga – Per-Inge Kruse & Zeynep Adali**

Talga presented its vertically integrated approach to battery materials, spanning the full value chain from graphite mining in Sweden to anode production and recycling. Per-Inge Kruse and Dr. Adali emphasized the company's strong focus on sustainability, highlighting their low-emission processes and the results of a life cycle assessment showing a 92% reduction in greenhouse gas emissions for their natural graphite compared to conventional alternatives.

Their product portfolio includes Talnode C (natural graphite anode), Talnode R (recycled graphite anode), silicon anode composites, and conductive additives. Dr. Adali shared technical insights into the performance of both natural and recycled anodes, as well as the successful purification of end-of-life battery graphite to battery-grade quality, demonstrating the feasibility of Talga's recycling technology.

The presentation concluded with updates on Talga's scaling strategy and efforts to establish industrial partnerships, reinforcing their position as a sustainable and high-performance supplier in the European battery materials ecosystem.

### **Key Takeaways and Next Steps**

- Several technologies presented show promising performance but require additional validation at pilot or demonstrator scale.
- Participants stressed the importance of aligning material innovations with battery performance targets, end-of-life strategies, and emerging European regulations.
- Collaboration between material developers and integrators is essential to ensure compatibility with current manufacturing processes and performance requirements.
- The workshop highlighted the potential of carbon materials derived from fossil fuel valorization as a strategic opportunity for sustainable anode production.

This session marks the second step in the dynamic we are building around advanced carbon materials, with a specific focus on their applications in energy storage. If you would like to get in touch with other participants or have any questions, don't hesitate to contact Polymeris. The B2Match platform remains accessible at the following [link](#). We encourage you to check it regularly and update your availability in the proposed time slots so that other participants can send you meeting requests. This will help you explore new opportunities and connect with registered participants.