ECGA'S FEEDBACK ON THE BIOECONOMY'S PLAN FROM THE EUROPEAN COMMISSION

How to integrate bio-based feedstocks in existing graphitisation infrastructure

The European Carbon and Graphite Association (ECGA) welcomes the European Commission's initiative to develop a Circular, Regenerative, and Competitive Bioeconomy. We strongly support efforts to integrate bio-based feedstocks into industrial processes, which align with our commitment to reducing costs and the environmental footprint of our products.

However, significant challenges remain for the carbon-based bioeconomy. Due to a lack of scale and a mismatch of physical and chemical properties, bio-based solutions cannot yet fully replace recycled feedstock or fossil-based precursors like petroleum coke. Nevertheless, they could be better integrated into the EU's existing graphitisation infrastructure.

This paper outlines technical and market barriers and proposes actionable solutions to accelerate the transition. Our key requests are:

- **To include carbon and graphite in all bioeconomy stakeholder workshops and policy plans.**
- **To provide support for technical validation and scaling-up strategies, in particular by**
    - Funding R&D programs to develop synthetic bio-based precursors (e.g., bio-pitch or bio-coke) with tailored properties (high carbon yield, purity, particle size).
    - Supporting cross-sectoral collaborations to optimize contaminant removal technologies.
    - Exploring hybrid processes that adapt existing furnace infrastructure to bio-based inputs.

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1. Material Science Challenges in Feedstock Integration

The integration of bio-based feedstocks into carbon and graphite production faces critical engineering hurdles. ECGA members are already working on those issues and will continue to do so in the future. However, financial support has been clearly lacking from both public entities and the market, both at the R&D and scale-up stages. We therefore hope that the new Bioeconomy Strategy from the Commission will improve the financial outlook for our forward-looking membership.

Particle Size Mismatch

Industrial carbon/graphite production requires precursors with controlled particle sizes (typically 50 µm–1 cm) to ensure uniform packing, heat transfer, and electrical conductivity in final products. However, many bio-based precursors emerge intrinsically too small from the carbonisation step. It is also not possible to agglomerate these ultrafine particles to meet industrial specifications. The presence of binder zones within a graphite block can disrupt the uniformity of thermal, mechanical, and electrical properties across the material. Those zones can create “hotspots” of high resistivity or thermal expansion, compromising performance in electrodes or refractory components.

Carbonisation and Graphitisation

Primary bio-based feedstocks (wood chips, kernels, agricultural waste) have typically carbon contents below 80%. Feeding those materials directly into a graphitisation furnace would be inefficient. It would result in excessive mass loss during carbonisation. It would also be a waste of energy, because energy consumption scales up with the volume of the feedstock.

To tackle this, a pre-graphitisation pyrolysis stage is necessary. But this stage must be precisely controlled in order to provide materials suitable for graphitisation. The degasification of biomass during carbonisation creates internal stresses in the carbon blocks. Large volumes of pyrolysis gases (e.g., CO, CH_4) generated during thermal decomposition must diffuse out of the material matrix. This means that, without proper precaution, bio-based carbon blocks are typically more porous and fragile than their fossil-based alternatives.

Furthermore, the molecular architecture of biopolymers such as lignin poses fundamental challenges for graphitisation. Unlike synthetic precursors (e.g., petroleum pitch), which exhibit hierarchical alignment of aromatic clusters, biomaterials’ inherently disordered and oxygen-rich structure lacks the structural requirements to form extended graphitic domains. Instead, persistent clusters of irregularities disrupt the progressive ordering of carbon layers during pyrolysis, even at extreme temperatures (>2000°C).

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Currently, those issues have received limited support from the EU. Funding programs such as the Circular Biobased Europe Partnership emphasize bioenergy applications (e.g., biogas, biofuels). Meanwhile, material-focused initiatives such as synthetic bio-pitch are not prioritised. Yet, without targeted investment to improve carbon retention, improve molecular alignment, or develop gas-mitigation strategies, bio-based precursors will struggle to compete with fossil-derived analogs in high-performance graphite applications.

Catalyst and Contamination

While catalytic additives can promote graphitic ordering in bio-based carbons, their practical application faces significant barriers.

First, more research is necessary to make sure that those additives systematically achieve uniform structural transformation at an industrial scale: localised interactions with the carbon matrix normally result in partial graphitisation, leaving adjacent regions amorphous. This heterogeneity undermines bulk material performance, as mechanical and electrical properties become spatially inconsistent.

Second, such additives are generally not true “catalysts” in the traditional sense, because they are consumed during graphitisation. This is a positive in the sense that it limits contamination of the final material, but this single-use nature also escalates costs, particularly for large-scale industrial processes.

Third, residual metallic impurities from the catalysts sometimes do persist in the final product, even after post-treatment. These contaminants prevent high-grade applications like lithium-ion battery anodes or semiconductor-grade graphite, as they degrade thermal stability and electrical conductivity.

Furthermore, this problem compounds with the presence of heterogeneous contaminants (metals, minerals, ash, sulphur) that typically occur when feedstocks of different origins are mixed (fossil-based, bio-based, recycled). These impurities jeopardise the high carbon purity required for applications like batteries, semiconductors, or steelmaking.

Finally, catalytic additives present significant challenges from an emissions control and waste management perspective. At graphitisation temperatures (>2500°C), additives may volatilize or react to form hazardous byproducts, what requires expensive post-combustion filters. And the acids used to leach off these catalysts from the final product generate hazardous waste streams too.

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2. Market and Supply Chain Barriers

Beyond technological challenges, ECGA and its members have identified the following market barriers to the development of bio-based feedstocks for the carbon and graphite sector.

Limited Scale

In the carbon and graphite sector, bio-based alternatives are currently limited to niche applications. Production volumes in the hundreds of tonnes are insufficient for large-scale processes. For example, electrode manufacturers require several ten thousand tonnes of petroleum coke annually, making direct substitution impractical for industries where consistent quality and reliable supply are essential.

Competition with Biofuels

Biofuels are set to increase demand for biomass. The ReFuelEU Aviation initiative will require approximately 17.3 million tonnes of biomass annually by 2035, severely limiting availability for ECGA members. This competition is exacerbated by subsidies and regulatory incentives favouring energy applications over material uses, resulting in pricing that disadvantages graphite producers.

Climate-Change Vulnerability

Biomass production is highly vulnerable to climate events, creating significant supply risks. Recent European droughts (2018, 2022) reduced biomass yields in affected regions. Unlike fossil feedstocks, which store well long-term, many bio-based precursors have limited shelf lives and require specialised storage. This leads to price volatility and supply uncertainty, complicating planning and increasing costs for industries reliant on consistent feedstock flows.

Fragmented Supply Chains

Europe's biomass landscape suffers from regional disparities in availability and processing capabilities. Nordic countries have abundant forestry resources but limited processing infrastructure, while the opposite is true elsewhere. This fragmentation, compounded by varying national policies and regulations, creates challenges for SMEs and startups. Without the resources to navigate these complexities, promising bio-based innovations struggle to reach commercial scale for integration into carbon and graphite supply chains.

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