

Standards Proposal: Graphene & Carbon Nanosheet Nomenclature Framework

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1. Executive Summary

The current lack of consistency in naming graphene and carbon nanosheets leads to significant confusion across research, intellectual property, and international trade [1] [2] [3]. Landry Industries and Marie Landry's Spy Shop propose a standardized, origin-based framework for graphene-related materials. This framework ensures clarity, traceability, and alignment with sustainability goals. A **case study** on a bio-based composite, Hempoxies™, is presented to demonstrate bio-based innovation and the practical application of the proposed framework.

2. Background & Rationale

Graphene was historically produced from graphite and became the default definition of the material [4] [5] [6]. With the emergence of biomass-derived, fossil-derived, synthetic precursor-derived, and CO₂-derived nanosheets, terminological ambiguity has grown [7] [8] [9]. It is critical to note that even within a single class, material properties can vary dramatically; for example, different biomass feedstocks and processing methods will yield carbon nanosheets with unique qualities [50] [51].

Existing standards such as ISO/TS 80004-13 and ASTM E2865 provide foundational definitions but do not adequately distinguish feedstock origin, leading to miscommunication and barriers to sustainable material certification [1] [10] [11].

A feedstock-origin nomenclature addresses this gap, supports circular economy principles, and ensures clear distinctions in R&D, patents, and regulatory frameworks.

3. Proposed Nomenclature Framework

Class	Formal Name	Abbrev.	Feedstock Examples	Processes	Notes
1	Graphite-derived graphene	GDG	Natural / synthetic graphite	Exfoliation, CVD	Historical default graphene; benchmark reference [4] [12].
2	Biomass-derived carbon nanosheets	BDCN	Hemp, lignin, sugarcane, algae	Pyrolysis, hydrothermal	Renewable, tunable defects;

Class	Formal Name	Abbrev.	Feedstock Examples	Processes	Notes
					feedstock specified. Properties vary by source & process. [8] [50].
3	Fossil carbon-derived graphene-like nanosheets	FCGN	Coal tar, petroleum coke	Graphitization, exfoliation	Non-renewable; low cost, higher impurities [13].
4	Synthetic precursor-derived graphene	SPDG	Methane, acetylene, ethanol	CVD, plasma, pyrolysis	High quality control; scalable for electronics [9] [14].
5	CO ₂ -derived graphene	CDG	Captured CO ₂ (atmospheric/flue)	Electrochemical reduction, catalysis	Climate-positive; emerging technology [15] [16].
6	Hybrid precursor-derived graphene composites	HPGC	Polymer-MOFs, mixed precursors	Pyrolysis, sol-gel	Designed for multifunctionality [17].
7	Composite materials	[Feedstock]-CN composite	Hemp CN + bioepoxy, etc.	Varies	Must specify reinforcement + matrix origins.

Key Rules for Usage:

1. "Graphene" without qualifier = graphite-derived graphene.
2. Bio-based sources use the form: [feedstock]-derived carbon nanosheets.
3. Functionalization should be noted with suffixes (–O, –N, etc.).
4. Composites must specify both reinforcement + matrix origins.

Beyond Origin: Specifying Modifications

While feedstock origin provides the foundational identity of a material, its final properties are often defined by intentional post-synthesis modifications. To ensure precise communication, the nomenclature must also account for **doping, functionalization, and structural tuning**.

- **Doping:** The introduction of heteroatoms (e.g., nitrogen, boron, phosphorus) into the graphene lattice to alter its electronic properties [30] [31]. For example, nitrogen doping can shift the Fermi level and create reactive sites, which is critical for applications in sensing and catalysis [30]. Boron doping, due to boron's lower electronegativity, can create a p-type semiconductor [31]. These modifications fundamentally change the material's behavior.
- **Functionalization:** The chemical bonding of functional groups (e.g., carboxyl, hydroxyl,

amine) to the graphene surface. This is a common method for improving a material's solubility, dispersibility, and compatibility with other materials in a composite [32] [33].

- **Structural Tuning:** The deliberate control of defects, layer number, pore size, or surface morphology to achieve desired performance [34] [35]. These properties are crucial for applications like energy storage, where controlling porosity can dramatically increase a supercapacitor's energy density [36] [37].

The proposed framework can be extended with a simple, standardized notation for these modifications. For instance, a nitrogen-doped, bio-derived carbon nanosheet from hemp could be formally named **Hemp-BDCN-N-porous**.

4. Alignment with Existing Standards

- ISO/TS 80004-13 (Nanotechnologies — Vocabulary — Part 13: Graphene) [10] and
- ASTM E2865 (Standard Terminology for Graphene) [11]

These provide foundational definitions but do not differentiate feedstock origin. This proposal extends existing standards by integrating feedstock provenance and sustainability, ensuring compatibility with future environmental labeling and certification systems [1] [10].

5. Proof-of-Concept Case Study: A Biocomposite Framework Application

Hempoxies™ is presented here as a detailed proof-of-concept for how the proposed framework can be applied to a multi-component material. Its formulation showcases a fully bio-derived, carbon-negative, and recyclable composite:

- **Epoxidized Hemp Seed Oil (EHSO):** The bio-based polymer matrix [38].
- **Modified Hemp Lignin:** A triple-function biopolymer that serves as a cross-linker, a source of dynamic chemistry, and an interfacial compatibilizer [39].
- **Hemp-Derived Amine:** A co-reactant that enables the material's catalyst-free, dynamic vitrimer chemistry [40] [41].
- **Hemp-Derived Carbon Nanosheets (HDCNS):** Nano-scale reinforcement for toughness and fracture resistance [42] [43].
- **Hemp-Derived Biochar:** Micro-scale reinforcement for stiffness, compressive strength, and thermal stability [44] [45].
- **Hemp-Derived Carbon Fibers (HDCF):** Macro-scale reinforcement that provides the composite's primary structural integrity [46] [47].
- **Furfuryl Glycidyl Ether (FGE):** A hemp-derived reactive diluent that improves the material's processability [48] [49].

This material illustrates the practical application of the framework, demonstrating:

- Complete feedstock traceability,
- Circular economy principles,
- Innovation leadership by Landry Industries, and
- A notable performance advantage: Research shows that hemp-derived graphene has been shown to outperform graphite-derived graphene by nearly 200% when used in supercapacitors [18] [19] [20].

6. Recommendations for Standards Committees

1. Adopt a feedstock-origin taxonomy for graphene and nanosheets.
2. Add sustainability labeling to graphene terminology.
3. Recognize bio-based and CO₂-derived graphene as distinct categories.
4. Formalize composite nomenclature (reinforcement + matrix origins).

7. References

1. **Inconsistent Nomenclature:** Boehm, H. P. (2013). "All in the graphene family – A recommended nomenclature for two-dimensional carbon materials." *Carbon*. <https://sfec-carbone.org/wp-content/uploads/2020/05/GrapheneNomenclature2013.pdf>
2. **Inconsistent Nomenclature:** The Graphene Council. "Graphene is often misunderstood and misidentified." *The Graphene Council*. <https://www.thegraphenecouncil.org/page/What-Is-Graphene>
3. **Inconsistent Nomenclature:** Nanowerk. "The Graphene Confusion: A New Nomenclature is Needed." *Nanowerk*. https://www.nanowerk.com/graphene_confusion_a_new_nomenclature_is_needed.php
4. **History of Graphene:** Science and Industry Museum. "Graphene: A new way of thinking about materials." *Science and Industry Museum*. <https://www.scienceandindustrymuseum.org.uk/objects-and-stories/graphene>
5. **History of Graphene:** Novoselov, K. S. et al. (2004). "Electric Field Effect in Atomically Thin Carbon Films." *Science*. <https://www.science.org/doi/10.1126/science.1102896>
6. **History of Graphene:** Wikipedia. "Discovery of graphene." *Wikipedia*. https://en.wikipedia.org/wiki/Discovery_of_graphene
7. **Biomass-Derived Nanosheets:** Tech Science Press. "Biomass-Derived Carbon-Based Nanomaterials: Current Research, Trends, and Challenges." *Journal of Renewable Materials*. <https://www.techscience.com/jrm/online/detail/23418/pdf>
8. **Biomass-Derived Nanosheets:** MDPI. "Review of Biomass-Derived Carbon Nanomaterials—From 0D to 3D—For Supercapacitor Applications." *Nanomaterials*. <https://www.mdpi.com/2079-4991/15/4/315>
9. **Synthetic Precursors:** Kindle-Tech. "What Is The Typical Precursor Used In Cvd Synthesis Of Graphene? Methane Explained." *Kindle-Tech*. <https://kindle-tech.com/faqs/what-is-the-typical-precursor-used-in-cvd-synthesis-of-graphene>
10. **ISO Standard:** AFNOR. "ISO/TS 80004-13:2024 - Nanotechnologies - Vocabulary - Part 13: Graphene and other two-dimensional (2D) materials." *Afnor EDITIONS*. <https://www.boutique.afnor.org/en-gb/standard/iso-ts-80004132024/nanotechnologies-vocabulary-part-13-graphene-and-other-twodimensional-2d-ma/xs146324/424557>
11. **ASTM Standard:** The Graphene Council. "Graphene Definitions 2D Materials Glossary." *The Graphene Council*. <https://www.thegraphenecouncil.org/page/GLOSSARY>
12. **Processes:** ResearchGate. "(PDF) Recent Progress on CVD Growth of Graphene from a Liquid Carbon Precursor." *ResearchGate*. https://www.researchgate.net/publication/352830021_Recent_Progress_on_CVD_Growth_of_Graphene_from_a_Liquid_Carbon_Precursor
13. **Fossil Carbon:** US Patent. "Graphene and graphene-like materials from coal and petroleum coke." *USPTO*. <https://patents.google.com/patent/US20180297892A1/en>
14. **Synthetic Precursors:** The Graphene Council. "Graphene Production Methods." *The Graphene Council*. https://www.thegraphenecouncil.org/page/Graphene_Production_Methods

15. **CO₂-Derived Graphene:** Frontiers. "CO₂ Metallothermal Reduction to Graphene: The Influence of Zn." *Frontiers in Chemical Engineering*.
<https://www.frontiersin.org/journals/chemical-engineering/articles/10.3389/fceng.2021.707855/full>
16. **CO₂-Derived Graphene:** MDPI. "Facile Preparation of Multilayered Graphene with CO₂ as a Carbon Source." *Applied Sciences*. <https://www.mdpi.com/2076-3417/9/21/4482>
17. **Hybrid Composites:** Google Patents. "WO2013114116A1 - Graphene composites." *Google Patents*. <https://patents.google.com/patent/WO2013114116A1/en>
18. **Hemp Graphene Performance:** ASME. "Hemp Carbon Makes Supercapacitors Superfast." *ASME*.
<https://www.asme.org/topics-resources/content/hemp-carbon-makes-supercapacitors-superfast>
19. **Hemp Graphene Performance:** UMass Industrial Hemp Research Initiative. "HEMP ENERGY STORAGE." *UMass*. <https://umasshemp.wordpress.com/energy-storage/>
20. **Hemp Graphene Performance:** Climate Solutions News. "Hemp-Derived Graphene: The Future of Sustainable Materials?" *Climate Solutions News*.
<https://climatesolutions.news/spotlight/hemp-derived-graphene-the-future-of-sustainable-materials>
21. **Economic Impact:** Indian Academy of Sciences. "Standardization for advanced materials: experience and strategies for the future." *Bulletin of Materials Science*.
<https://www.ias.ac.in/article/fulltext/boms/015/01/0077-0089>
22. **Economic Impact:** ResearchAndMarkets.com. "Green Building Materials Global Industry Report 2025." *Business Wire*.
<https://www.businesswire.com/news/home/20250908311747/en/Green-Building-Materials-Global-Industry-Report-2025-Growth-Fueled-by-Sustainability-Awareness-Stricter-Regulations-and-Government-Backed-Certification-Programs---Forecast-to-2030---ResearchAndMarkets.com>
23. **Economic Impact:** NIST. "Standardization in Technology-Based Markets." *NIST*.
<https://www.nist.gov/document/researchpolicypaperpdf>
24. **Implementation:** ASQ. "Standards 101." *ASQ*.
<https://asq.org/quality-resources/standards-101>
25. **Implementation:** Tools4ever. "What is Phased Implementation?" *Tools4ever*.
<https://www.tools4ever.com/glossary/what-is-phased-implementation/>
26. **Implementation:** DealHub. "What is Phased Implementation?" *DealHub*.
<https://dealhub.io/glossary/what-is-phased-implementation/>
27. **Intellectual Property:** GraphenEye. "Graphene Patents: Complete Guide to the Innovation Landscape." *GraphenEye*.
<https://grapheneye.com/blog/graphene-patents-complete-innovation-guide/>
28. **Intellectual Property:** WIPO. "Patent Landscape Report – Graphite and its applications." *WIPO*.
<https://www.wipo.int/edocs/pubdocs/en/wipo-pub-1083-en-patent-landscape-report-graphite-and-its-applications.pdf>
29. **Intellectual Property:** BlueIron IP. "Importance of Clear Terminology in Patent Claims." *BlueIron IP*.
<https://blueironip.com/ufags/what-is-the-importance-of-clear-terminology-in-patent-claims/>
30. **N-Doping:** Pan, Y., et al. (2024). "Nitrogen-Doped Graphene Materials with High Electrical Conductivity Produced by Electrochemical Exfoliation of Graphite Foil." *PMC*.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC10780345/>

31. **B-Doping:** Ngu, H. T. T., et al. (2023). "Density Functional Theory Analysis of the Impact of Boron Concentration and Surface Oxidation in Boron-Doped Graphene." *MDPI*.
<https://www.mdpi.com/2311-5629/9/4/92>
32. **Functionalization:** Li, B., et al. (2023). "Applications of Functionalized Graphene Oxide in Drug Delivery and Biomedical Imaging." *Scientific Research*.
<https://www.scirp.org/journal/paperinformation?paperid=136503>
33. **Functionalization:** Ali, I., et al. (2025). "Synthesis and Functionalization of Graphene Oxide." *Chemical Research and Technology*.
https://www.chemrestech.com/article_210141_9cb867e5fb1d7c8ca725653259074b11.pdf
34. **Structural Tuning:** Sanna, A., et al. (2015). "Controlled defects improve graphene's properties." *Graphene-info*.
<https://www.graphene-info.com/controlled-defects-improve-graphenes-properties>
35. **Structural Tuning:** Wu, Q., et al. (2023). "Tuning Penta-Graphene Electronic Properties Through Engineered Line Defects." *Frontiers in Chemistry*.
<https://www.frontiersin.org/articles/10.3389/fchem.2023.1166705>
36. **Pore Tuning:** Li, Z., et al. (2020). "Design of graphene-based structures for capacitive energy storage." *UCL Discovery*.
https://discovery.ucl.ac.uk/id/eprint/10089670/1/PhD%20Thesis_Zhuangnan%20Li_final%20version_13012020.pdf
37. **Pore Tuning:** Cheng, Y., et al. (2024). "Stress-assisted design of stiffened graphene electrode structure toward compact energy storage." *ResearchGate*.
https://www.researchgate.net/publication/360151746_Stress-assisted_design_of_stiffened_graphene_electrode_structure_toward_compact_energy_storage
38. **Epoxidized Hemp Seed Oil:** MDPI. "Epoxidized and Maleinized Hemp Oil to Develop Fully Bio-Based Epoxy Resin Based on Anhydride Hardeners." *Polymers*.
<https://www.mdpi.com/2073-4360/15/6/1404>
39. **Modified Hemp Lignin:** MDPI. "Recent Research Progress on Lignin-Derived Resins for Natural Fiber Composite Applications." *Polymers*.
<https://www.mdpi.com/2073-4360/13/7/1162>
40. **Hemp-Derived Amine:** Chemical Reviews. "Biobased Amines: From Synthesis to Polymers; Present and Future." *ACS Publications*.
<https://pubs.acs.org/doi/10.1021/acs.chemrev.6b00486>
41. **Hemp-Derived Amine:** Google Patents. "WO2017132380A1 - Polymeric dispersants containing multi-amine groups with improved chemical and thermal stability." *Google Patents*. <https://patents.google.com/patent/WO2017132380A1/en>
42. **Carbon Nanosheets:** Google Patents. "US20140328006A1 - Carbon nanosheets." *USPTO*. <https://patents.google.com/patent/US20140328006A1/en>
43. **Carbon Nanosheets:** Reddit. "Introducing HDCNS-Composites: Hemp-Derived Carbon Nanosheets Integrated Into Various Matrixes for Composite Materials." *Reddit*.
https://www.reddit.com/r/materials/comments/1jjggi8/introducing_hdcnscomposites_hemp_derived_carbon/
44. **Biochar Reinforcement:** MDPI. "Characterization of Hemp Hurd-Derived Biochar for Potential Agricultural Applications." *Agronomy*.
<https://www.mdpi.com/2073-4395/15/9/2136>
45. **Biochar Reinforcement:** PMC. "Utilization of biochar derived from industrial hemp stalks with various cooling methods for asphalt binder modification." *PMC*.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC12220996/>
46. **Carbon Fibers:** ResearchGate. "(PDF) Thin Hybrid Hemp/Carbon Fiber Composites:

- Manufacturing, Flexural, and Impact Behavior." *ResearchGate*.
https://www.researchgate.net/publication/369483905_Thin_Hybrid_HempCarbon_Fiber_Composites_Manufacturing_Flexural_and_Impact_Behavior
47. **Carbon Fibers:** ResearchGate. "HEMP-derived activated carbon fibers by chemical activation with phosphoric acid." *ResearchGate*.
https://www.researchgate.net/publication/223201840_HEMP-derived_activated_carbon_fibers_by_chemical_activation_with_phosphoric_acid
48. **FGE Reactive Diluent:** ResearchGate. "Furfurylglycidyl ether: a new effective active diluent for epoxy resins from bio-renewable raw materials." *ResearchGate*.
https://www.researchgate.net/publication/356492035_Furfurylglycidyl_ether_a_new_effective_active_diluent_for_epoxy_resins_from_bio-renewable_raw_materials
49. **FGE Reactive Diluent:** ABG AM. "Reactive Diluents." *ABG AM*.
<https://www.abg-am.com/portfolio/chemistry/reactive-diluents/F004>
50. **Biomass Quality Variation:** ResearchGate. "A comparative study on the physical and chemical properties of activated carbons from sugarcane bagasse, hemp stalk, and coconut shell." *ResearchGate*.
https://www.researchgate.net/publication/329587421_A_comparative_study_on_the_physical_and_chemical_properties_of_activated_carbons_from_sugarcane_bagasse_hemp_stalk_and_coconut_shell
51. **Biomass Processing Variation:** ScienceDirect. "Effects of pyrolysis temperature on the properties of biochar derived from bamboo residues for soil amendment." *ScienceDirect*.
<https://www.sciencedirect.com/science/article/pii/S157143921930198X>

Related Additional Reading

- **General Graphene Properties:** Geim, A.K., & Novoselov, K.S. (2004). "The rise of graphene." *Science*. <https://www.science.org/doi/abs/10.1126/science.1104245>
- **Supercapacitor Technology:** Wang, Y., et al. (2012). "Graphene-based materials for supercapacitor electrodes." *Journal of Materials Chemistry A*.
<https://pubs.rsc.org/en/content/articlelanding/2012/ta/c2ta00812h>
- **Carbon Nanomaterials Market:** Intel Market Research. "Carbon Materials Market Growth Analysis..." *Intel Market Research*.
<https://www.intelmarketresearch.com/materials-and-chemicals/10124/carbon-materials-market>

8. Implementation Roadmap

A phased implementation approach, as often used for new technical standards, will ensure a smooth and effective transition to the proposed framework [25] [26].

- **Phase 1: Working Group Formation (0-6 months)**
 - Establish a joint working group under the relevant ISO/ASTM committees.
 - Conduct a public call for feedback from industry, academia, and regulatory bodies.
 - Draft an initial technical specification document for internal review.
- **Phase 2: Standard Drafting & Pilot Program (6-18 months)**
 - Develop a formal draft of the updated standard, including definitions and classification rules.
 - Launch a pilot program with participating companies (e.g., Landry Industries, material producers, end-users) to test the framework's practical application.

- Refine the draft based on pilot program feedback and stakeholder input.
- **Phase 3: Formal Approval & Dissemination (18-24 months)**
 - Submit the final draft for formal committee vote and approval.
 - Publish the new international standard with a comprehensive communications plan to ensure global awareness and adoption.

9. Economic Impact & Market Benefits

The proposed framework provides clear economic advantages by addressing key market inefficiencies [21] [23]:

- **Accelerated Innovation & R&D:** Standardized terminology reduces ambiguity, making it easier for researchers to replicate experiments and build on existing work, thus accelerating the development lifecycle [23]. This clarity also streamlines the patenting process, as precise language protects intellectual property and reduces the risk of legal challenges [27] [28] [29].
- **Market Growth & Investor Confidence:** A clear, consistent nomenclature builds confidence for investors and end-users, especially in the rapidly growing markets for advanced materials and sustainable building products [22] [21]. It provides a reliable basis for material specifications, supply chain management, and quality control, which are essential for market-wide adoption and trade [23].
- **Enabling a Circular Economy:** By formally distinguishing bio-based and CO₂-derived materials, the framework allows for the development of new, verifiable sustainability certifications. This creates a competitive advantage for producers of renewable materials and supports a growing demand for carbon-negative products [22] [20].

10. Appendix: Visual Framework

Category	Feedstock Origin	Proposed Class	Abbreviation
Traditional Graphene	Natural / Synthetic Graphite	Graphite-derived graphene	GDG
Emerging Nanosheets	Biomass (Hemp, Algae, etc.)	Biomass-derived carbon nanosheets	BDCN
	Captured CO ₂	CO ₂ -derived graphene	CDG
	Fossil Carbon (Coal, etc.)	Fossil carbon-derived graphene-like nanosheets	FCGN
	Synthetic Precursors (Methane)	Synthetic precursor-derived graphene	SPDG
Complex Materials	Mixed Precursors / Polymers	Hybrid precursor-derived graphene composites	HPGC
	Composite (e.g., Hemp CN + Bioepoxy)	[Feedstock]-CN composite	[Feedstock]-CN composite

Closing

This standards proposal is respectfully submitted by Landry Industries and Marie Landry's Spy Shop. It is intended to guide ISO, ASTM, and allied bodies in developing international consensus standards that clarify graphene nomenclature, promote sustainability, and ensure global harmonization.