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Title: Diamond Composites: An Open-Source Recipe for Sustainable, High-Performance Materials from Hemp

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[Diamond Composites](#)

Abstract

This paper introduces "Diamond Composites," a novel class of sustainable materials poised to revolutionize the field of composites. By harnessing the remarkable properties of hemp-derived components – carbon nanosheets ("hemp graphene"), hemp oil, and lignin – Diamond Composites offer a potentially cost-effective and environmentally friendly alternative to traditional graphene-epoxy composites. This paper outlines the theoretical framework for Diamond Composites, highlighting their potential for achieving comparable or superior performance characteristics. Crucially, it declares the intention to release all intellectual property related to Diamond Composites into the public domain, offering an open-source recipe as a gift to the world. This approach aims to foster global collaboration, accelerate innovation, and promote the widespread adoption of sustainable materials for a more equitable and environmentally conscious future.

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Diamond Composites: An Open-Source Recipe for Sustainable, High-Performance Materials from Hemp

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1. Introduction

Composite materials have become indispensable in modern society, finding applications in diverse sectors ranging from aerospace and automotive to construction and consumer goods. These materials, formed by combining two or more distinct constituents with different physical or chemical properties, offer a unique blend of strength, stiffness, lightweight, and design flexibility. However, the current landscape of composite materials is not without its limitations. Many widely used composites rely heavily on petroleum-derived components, raising concerns about environmental sustainability and resource depletion. Moreover, the high cost of certain high-performance materials, such as graphene, can limit their accessibility and widespread adoption.

In response to these challenges, this paper introduces a novel class of composite materials termed "Diamond Composites." This innovative approach harnesses the potential of hemp-derived components to create sustainable and potentially cost-effective alternatives to traditional composites. Diamond Composites primarily consist of hemp-derived carbon nanosheets ("hemp graphene"), hemp oil as a matrix, and hemp lignin as a curing agent. This unique combination promises to deliver exceptional performance characteristics while minimizing environmental impact.

The objective of this paper is twofold. Firstly, it aims to present the theoretical foundation for Diamond Composites, outlining their composition, potential properties, and the rationale behind their development. Secondly, and perhaps most importantly, this paper declares the intention to release all intellectual property related to Diamond Composites into the public domain. This open-source approach seeks to foster global collaboration, accelerate innovation, and promote the widespread adoption of sustainable materials. By offering this technology as a gift to the world, we hope to inspire researchers, industries, and individuals to contribute to the advancement of Diamond Composites and unlock their full potential for the benefit of society and the planet.

2. Background

The foundation of Diamond Composites lies in the remarkable properties of hemp-derived carbon nanosheets, often referred to as "hemp graphene." This innovative material was first reported in 2013 by researchers at the University of Alberta, who developed a method for producing these nanosheets from hemp bast fiber. [1] The process involves a hydrothermal synthesis treatment, leveraging the unique multi-layered structure of hemp bast fiber composed of cellulose, hemicellulose, and lignin. [2] This results in interconnected, partially graphitic carbon nanosheets with high specific surface area, significant mesoporosity, and good electrical conductivity. [3]

These characteristics make hemp-derived carbon nanosheets particularly attractive for various applications, including supercapacitors, where they have demonstrated

exceptional performance. [4] Notably, the University of Alberta holds a patent related to the use of these nanosheets in supercapacitor applications. However, the concept of Diamond Composites extends beyond energy storage, envisioning the integration of these nanosheets into a hemp-based epoxy matrix for broader structural and functional applications.

Hemp oil, extracted from the seeds of the hemp plant, is a promising candidate for the matrix material in Diamond Composites. It is a renewable resource with excellent binding properties and has been explored in various bio-based polymer applications. [5] Furthermore, hemp lignin, a byproduct of hemp processing, can serve as a sustainable curing agent. Lignin, a complex polymer found in the cell walls of plants, exhibits strong adhesive properties and can enhance the mechanical strength and thermal stability of composites. [6]

By combining hemp-derived carbon nanosheets with hemp oil and lignin, Diamond Composites offer a unique opportunity to create high-performance materials derived entirely from renewable resources. This approach not only addresses environmental concerns but also potentially reduces costs compared to traditional composites reliant on non-renewable materials like petroleum-based epoxy resins and expensive graphene.

[1] Mitlin, D., et al. (2013). Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy. *ACS Nano*, 7(6), 5122-5131.¹ [2] Ibid. [3] Ibid. [4] Ibid. [5] Mohanty, A. K., Misra, M., & Drzal, L. T. (2002). Sustainable bio-composites from renewable resources: Opportunities and challenges in the green materials²world. *Journal of Polymers and the Environment*, 10(1-2), 19-26.³ [6] Laurichesse, S., & Avérous, L. (2014). Chemical modification of lignins: Towards biobased polymers. *Progress in Polymer Science*, 39(7), 1266-1290.⁴

3. Theoretical Framework

Diamond Composites are envisioned as a unique class of bio-based composite materials with the potential to rival or even surpass the performance of conventional graphene-epoxy composites. The core composition of Diamond Composites involves three primary components, all derived from the hemp plant:

- **Hemp-derived carbon nanosheets ("hemp graphene"):** These nanosheets, produced through the hydrothermal processing of hemp bast fiber, serve as the primary reinforcing agent in Diamond Composites. Their high surface area, interconnected structure, and inherent electrical conductivity contribute to enhanced mechanical strength, stiffness, and potential multi-functional properties (e.g., thermal and electrical conductivity).
- **Hemp oil:** Extracted from hemp seeds, this renewable oil acts as the matrix material, binding the hemp nanosheets together. Hemp oil possesses excellent adhesive properties and can be modified or blended with other

bio-based resins to optimize the viscosity, curing characteristics, and overall performance of the composite.

- **Hemp lignin:** A byproduct of hemp processing, lignin serves as a sustainable curing agent for the composite. Its natural adhesive properties and rigid structure contribute to enhanced mechanical strength and thermal stability. Additionally, utilizing lignin as a curing agent reduces reliance on synthetic chemicals and promotes a circular economy within the hemp industry.

The synergistic interaction between these three components is crucial to achieving the desired properties in Diamond Composites. The hemp nanosheets, dispersed within the hemp oil matrix, form a reinforcing network that enhances the material's strength and stiffness. The lignin, acting as a cross-linking agent, binds the matrix and reinforcement together, further improving the composite's mechanical integrity and durability.

It is hypothesized that by carefully controlling the concentration and dispersion of hemp nanosheets, optimizing the hemp oil matrix formulation, and tailoring the curing process with lignin, Diamond Composites can achieve properties comparable to, or even exceeding, those of graphene-epoxy composites. This includes high tensile strength, flexural modulus, impact resistance, and potentially enhanced electrical and thermal conductivity.

Furthermore, the inherent versatility of Diamond Composites allows for a wide range of variations in composition and processing techniques. By incorporating additives, such as natural fibers, bio-based fillers, or other nanomaterials, and by adjusting processing parameters like temperature, pressure, and curing time, it is possible to tailor the material's properties for specific applications. This adaptability opens up exciting possibilities for designing Diamond Composites with customized characteristics to meet the demands of various industries and engineering challenges.

4. Open-Source Approach

In a departure from traditional intellectual property practices, this paper declares the intention to release all knowledge and information pertaining to the composition, fabrication, and application of Diamond Composites into the public domain. This decision is driven by a profound belief in the power of open-source collaboration to accelerate innovation, promote sustainability, and ensure equitable access to technological advancements.

The choice to forgo patent protection for Diamond Composites stems from several key motivations:

- **Fostering Global Collaboration:** By making the Diamond Composite recipe freely available, we aim to encourage researchers, engineers, and innovators

worldwide to explore, experiment, and contribute to the development of this promising material. Open collaboration can lead to rapid advancements, diverse applications, and a collective pool of knowledge that benefits society as a whole.

- **Accelerating Innovation:** Removing barriers to entry, such as licensing fees and patent restrictions, can significantly accelerate the pace of innovation. Open-source materials science allows for a more inclusive and dynamic research environment, where individuals and institutions can freely build upon existing knowledge and contribute their unique expertise.
- **Promoting Sustainability:** Diamond Composites represent a sustainable alternative to traditional composites, and their open-source nature further amplifies their positive environmental impact. By making this technology readily accessible, we hope to encourage its adoption and contribute to a more sustainable future for materials science and manufacturing.

The potential benefits of an open-source approach to materials science are numerous. It can lead to:

- **Increased Accessibility:** Open-source materials are readily available to everyone, regardless of their financial resources or institutional affiliations. This democratizes access to cutting-edge technology and empowers individuals and communities to develop solutions tailored to their specific needs.
- **Reduced Costs:** Eliminating patent licensing fees and proprietary restrictions can significantly reduce the cost of materials and manufacturing processes. This makes advanced materials more affordable and accessible for a wider range of applications.
- **Rapid Development:** Open collaboration and knowledge sharing can accelerate the development cycle of new materials and technologies. By fostering a community of contributors, we can collectively overcome challenges, optimize performance, and unlock the full potential of Diamond Composites.

This open invitation extends to researchers, industries, entrepreneurs, and makers worldwide. We encourage you to explore the possibilities of Diamond Composites, experiment with different formulations and applications, and contribute your findings to the growing body of open-source knowledge. Together, we can transform this promising concept into a reality and pave the way for a more sustainable and innovative future.

5. Future Directions

The journey of Diamond Composites is just beginning. While the theoretical framework presented in this paper provides a strong foundation, the true potential of these materials will be realized through continued research, development, and

collaboration. The following outlines key future directions for the advancement of Diamond Composites:

5.1 Proof of Concept and Material Characterization

The immediate next step is to create a physical prototype – the first "blob" of Diamond Composite. This will involve sourcing high-quality hemp-derived components, optimizing processing parameters, and fabricating a sample material. Following successful fabrication, rigorous material characterization is crucial. This includes:

- **Mechanical testing:** Assessing tensile strength, flexural modulus, impact resistance, and fatigue properties.
- **Thermal analysis:** Determining thermal conductivity, stability, and degradation temperatures.
- **Electrical characterization:** Measuring electrical conductivity and exploring potential for applications in electronics and sensors.
- **Microscopy and spectroscopy:** Analyzing the microstructure and chemical composition of the composite to understand the interactions between components.

This comprehensive characterization will provide critical data to validate the theoretical framework and compare the performance of Diamond Composites to existing materials.

5.2 Exploring Applications

Diamond Composites hold immense potential for a wide range of applications across diverse industries. Some promising areas include:

- **Lightweight and sustainable construction materials:** Replacing traditional concrete and steel with Diamond Composites in building components, offering reduced environmental impact and potentially improved performance.
- **Automotive and aerospace components:** Utilizing Diamond Composites in vehicle bodies, interior panels, and aircraft parts, reducing weight and improving fuel efficiency.
- **Consumer goods:** Developing durable and eco-friendly products such as sporting goods, furniture, and electronic casings.
- **Biomedical applications:** Exploring the potential of Diamond Composites for biocompatible implants, scaffolds, and drug delivery systems.

Further research and development will be needed to tailor the properties of Diamond Composites for specific applications and optimize their performance in real-world scenarios.

5.3 Collaborative Research and Development

The open-source nature of Diamond Composites calls for a collaborative approach to research and development. We encourage researchers, institutions, and industries to:

- **Share knowledge and findings:** Disseminate research results, processing techniques, and application discoveries through open-access publications, online platforms, and collaborative workshops.
- **Develop standardized testing protocols:** Establish standardized methods for evaluating the properties of Diamond Composites to ensure consistency and comparability across different studies.
- **Explore diverse applications:** Investigate the potential of Diamond Composites in various fields, pushing the boundaries of their capabilities and uncovering new possibilities.
- **Contribute to a global knowledge base:** Build a comprehensive repository of information on Diamond Composites, including material properties, processing techniques, and application examples.

By working together and sharing knowledge freely, we can accelerate the development and adoption of Diamond Composites, contributing to a more sustainable and innovative future for materials science and engineering.

This paper has presented the theoretical foundation for Diamond Composites and declared their open-source nature. The future of this promising material lies in the hands of the global community. We invite you to join us on this journey of exploration, innovation, and collaboration to unlock the full potential of Diamond Composites for the benefit of society and the planet.

6. Acknowledgments

This work would not have been possible without the inspiration drawn from the pioneering research on hemp-derived carbon nanosheets conducted at the University of Alberta. The author acknowledges the contributions of Dr. David Mitlin and his team for their groundbreaking work in this field.

Gratitude is also extended to the global community of researchers, innovators, and advocates who champion the development and utilization of sustainable materials. Your dedication to creating a more environmentally responsible future serves as a constant source of inspiration.

Finally, a special acknowledgment is given to the open-source movement, which embodies the spirit of collaboration, knowledge sharing, and collective progress. Your commitment to making technology and information accessible to all is instrumental in driving positive change in the world.

-Marie Seshat Landry