Science and Technology of New Integrated Microwave Plasma Pyrolysis/Microwave Plasma/Hot Filament Chemical Vapor Deposition Processes for Flexible Hemp-Ultrananocrystalline Diamond Transformation

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1. Introduction

Recently, our group demonstrated transformation of natural fungal mycelium, into a "myco-diamond" matrix containing ultrananocrystalline diamond (UNCD) [1]. This transformation was produced via a novel microwave pyrolysis process (MPP), achieved quickly/efficiently in a plasma reactor built by integration of a glass tube inside a low-cost kitchen microwave oven (Fig 1 (a),) which enabled producing the MPP process via creation of an Ar gas-plasma, created by microwave power coupling into Ar gas flown though the reactor.

2. MPP Induced Transformation of Flexible Hemp Canvas into Flexible Linen-Type UNCD

The R&D described in this abstract relates to the materials science/technology development recently started by the authors, focused on applying the novel MPP process for transformation of flexible hemp canvas (Fig. 1 (b)) into high-value end nanocarbon material in flexible linen-form fabric (Fig. 1 (c) and 1 (d)), with the UNCD structure (Fig. 1 (e)). The MPP-induced transformation of flexible hemp into UNCD was characterized using complementary structural (SEM (Figs. 1 (e), (h), (i), (j)) and HRTEM (Figs. 1 (f) and (k)) imaging), physical (mechanical bending (Figs. 1 (c) and 1(d)), chemical (Raman analysis (Figs. 1 (g) and (l)), techniques, which showed that the MPP transformed flexible hemp canvas exhibits hierarchical porosity at the macro, micro, and nanoscales (Figs. 1 (e-k)). A mechanism will be discussed to explain the flexible hemp-UNCD transformation.

Further functionalization and enhancement of the MPP transformed flexible hemp to UNCD was demonstrated via Microwave Plasma Chemical Vapor Deposition (MPCVD), used to grow UNCD layer conformally on the fibers of the hemp material, and Hot filament Chemical Vapor Deposition (HFCVD), used to grow electrically conductive N-UNCD layer on the fibers-surface, which resulted in the production of electrically conductive flexible N-UNCD linen.

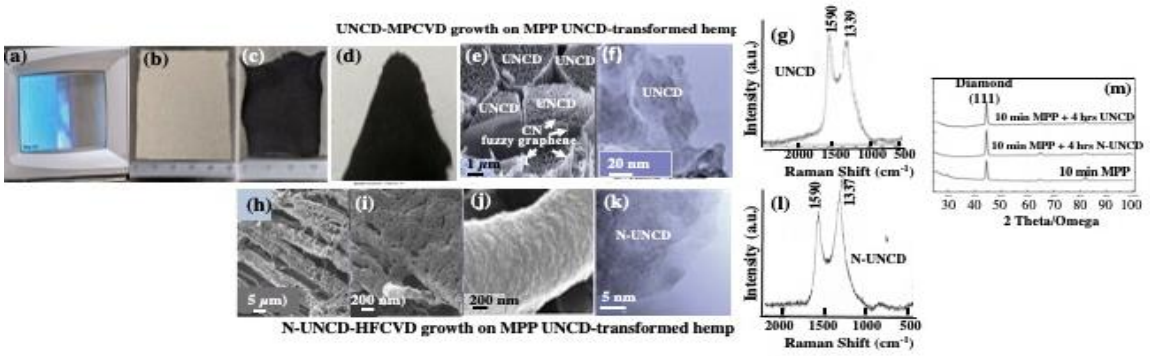

Figure 1. (a) Commercial microwave oven-based MPP system; (b) flexible virgin hemp canvas; (c) flat and (d) bent hemp-UNCD transformed linen; (e) SEM image of transformed hemp-UNCD linen; (f) HRTEM image of MPCVD coated MPP UNCD transformed hemp; (g) Raman spectrum characteristic of MPCVD-UNCD; (h) and (i) low magnification of HFCVD N-UNCD coated MPP hemp-UNCD transformed linen; (i) high magnification N_UNCD conformally coated hemp fiber; (k) HRTEM of N-UNCD films on MPP UNCD transformed hemp; (l) Raman spectrum characteristic of N-UNCD grown by HFCVD; (m) XRD analysis. Flexible transformed hemp-UNCD linen may provide new masks/fabric protection from viral molecules.

3. References

1. B. E. Stein, O. Auciello, M. J. Arellano-Jimenez, and B. R. Perez, "Fungal Mycelium Conversion into Ultrananocrystalline Diamond via Microwave Plasma Pyrolysis", ACS Sustainable Chemistry & Engineering, vol.10 (10**),** 3211–3218 (2022).