Laser Ablation Synthesis of Carbon-Phosphide Clusters – a Way Towards C-P Polymers

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Recently, carbon-phosphide (C-P) polymers are coming to scene. They can be synthesized e.g. via plasma deposition from CH_4 and PH_3 gas mixture.[1] The C-P polymer found already application in optoelectronics[2] and C-P nano-composites in lithium and sodium batteries.[3, 4]

In this work, we studied the generation of carbon-phosphide $C_mP_n^{\pm}$clusters via laser ablation of several nano-composites of nanodiamonds (ND) or graphene (G), with red or black phosphorus (RP or BP) or phosphorene: ND-phosphorene, ND-RP, ND-BP, G-RP, G-BP, etc.) using pulsed laser (337 nm) in a mass spectrometer as a kind of synthesizer. All nano-composites used in the study were characterized by electron microscopy. Phosphorene was prepared by liquid exfoliation from black phosphorus in N-methyl-2-pyrrolidone solvent using ultrasonication.[5] We demonstrated generation of several series of $C_mP_n^+$ cluster ions: C_mP^+ (m=3–47), $C_mP_2^+$ (m=2–44), $C_mP_3^+$ (m=1–42), $C_mP_4^+$ (m=1–39), $C_mP_5^+$ (m=1–37), $C_mP_6^+$ (m=1–34), $C_mP_7^+$ (m=1–31), $C_mP_8^+$ (m=1–29), $C_mP_9^+$ (m=1–26), $C_mP_{10}^+$ (m=1–24), $C_mP_{11}^+$ (m=1–21), and $C_mP_{12}^+$ (m=1–19) clusters were detected. LDI of nanodiamond composites with red/black phosphorus or with phosphorene yielded $C_{24}P_{5+2n}^+$ (n=0–28), $C_{24}P_{5+2n}^+$ (n=0–16), and $C_{24}P_{5+2n}^+$ (n=0–14), respectively. Dominant clusters with the highest intensities were C_7P^+, $C_6P_3^+$, $C_{10}P_3^+$, and $C_{13}P_5^+$, while graphene was evaluated as the most suitable precursor for C-P clusters generation. The results of this work were recently published.[6]

Concluding, in total, over 300 new carbon–phosphide clusters were generated. These results are opening the possibility to produce polymeric C-P monolayers via pulsed laser deposition with wide range of potential applications.

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