Sustainable Synthesis of Graphene from Municipal Waste Plastics through Pyrolysis

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Abstract: Plastic waste poses a widespread and growing threat to global ecosystems, biodiversity, and human well-being. Its persistence in the environment, with decomposition times ranging from centuries to millennia, leads to significant contamination of terrestrial, freshwater, and marine habitats. Plastics disrupt the ecological balance throughout their entire lifecycle, from fossil fuel extraction and production, which contribute to habitat loss and pollution, to their accumulation as waste, which degrades habitats and hinders ecosystem services vital for livelihoods and food production [1]. The production and incineration of plastics also make substantial contributions to greenhouse gas emissions, worsening climate change and its associated effects on ecosystems [2]. Addressing plastic waste demands, integrated catalytic pyrolysis was used to transform municipal waste plastics (MWP) into graphene-like carbon, which was then upgraded in a solid phase. In an inert environment, pre-processed plastic feedstocks (PE, PP, PS, and PET with reduced PVC content) were pyrolysed at temperatures ranging from 100 °C to 450°C to produce non-condensable gases, pyrolysis oil, and carbon-rich char. The char underwent additional processing, including high-temperature annealing (600-950°C) to promote graphitic ordering, ball milling for mechanical exfoliation, and acid washing to remove ash and catalyst [3]. The fabrication of relatively few-layer graphene-like domains with a low defect density and a large surface area was validated by characterisation using Raman spectroscopy, XRD, TEM, and BET. By diverting persistent plastic trash from the environment and turning it into valuable nanomaterials for use in composites, energy storage, conductive inks, and catalysis, this technique promotes a sustainable circular economy.

References

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[2] Zheng J, Suh S, Nature Climate Change, 2019, 374-8.
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Figure

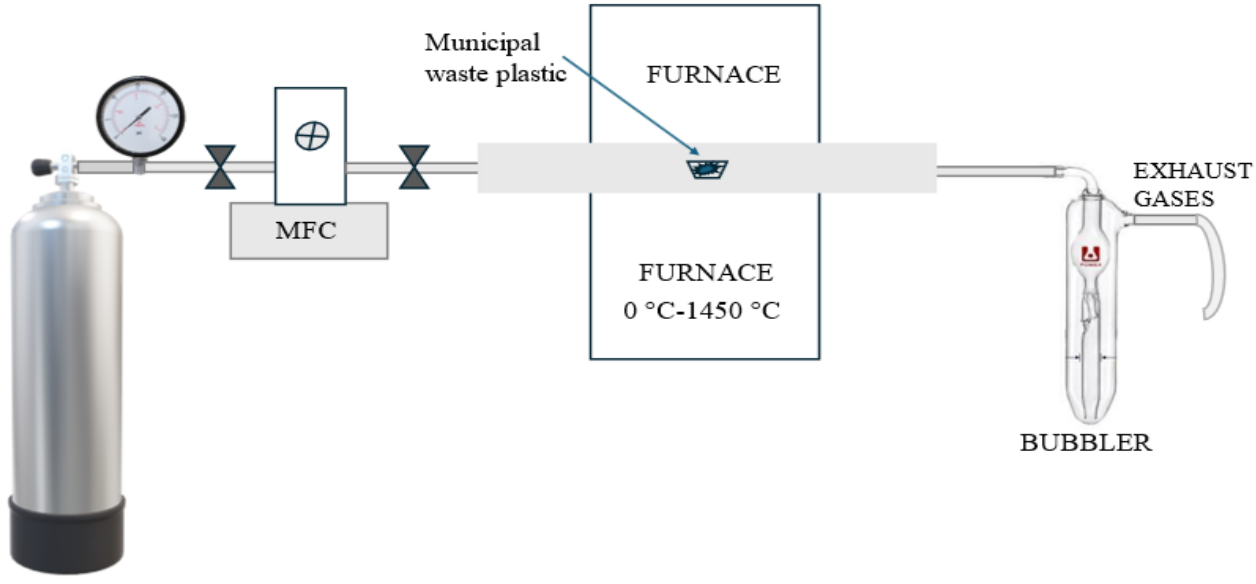

Figure 1: Schematic representation for catalytic pyrolysis of municipal waste plastic to graphene