Upcycling Plastic Waste into Graphitic Carbons

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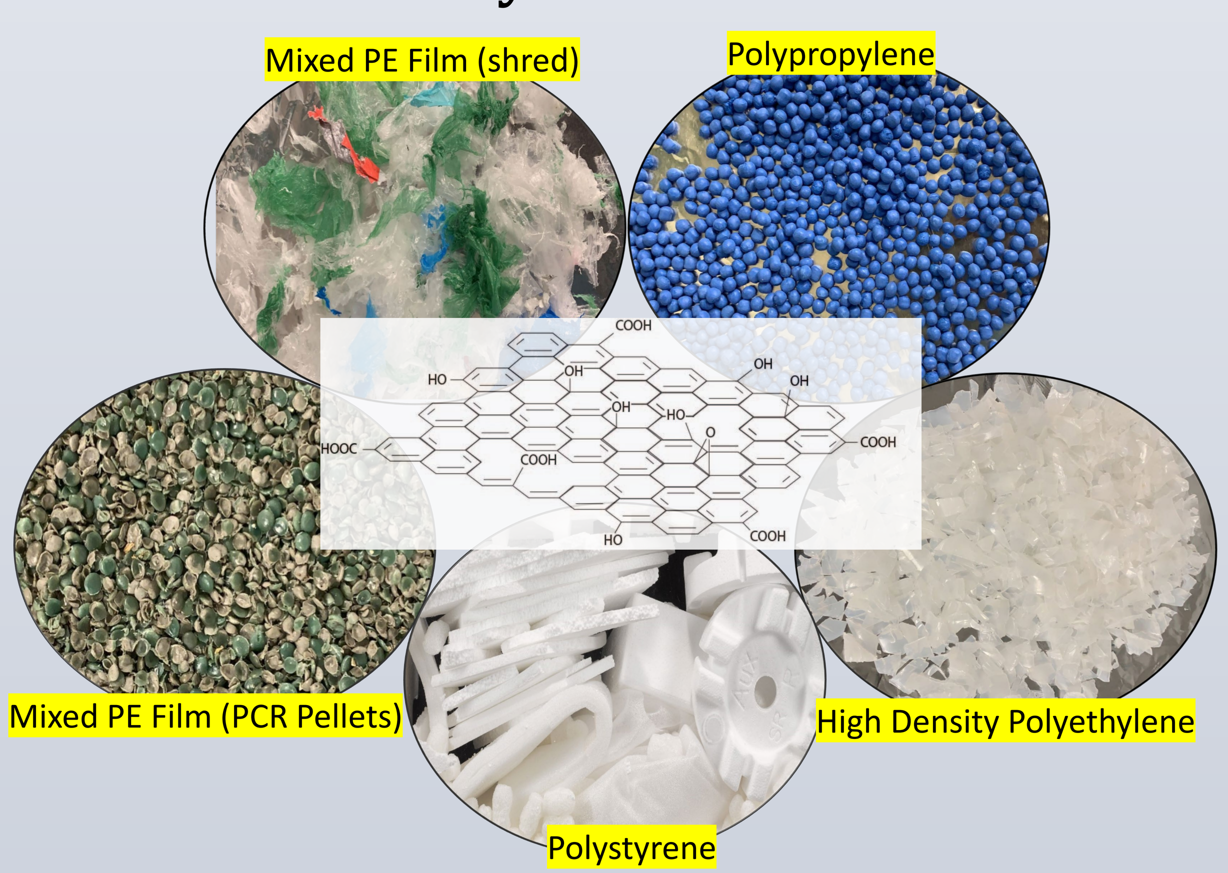
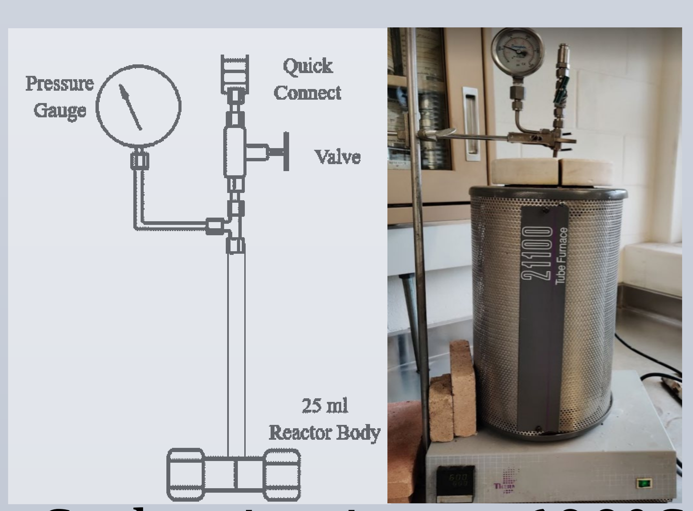
ABSTRACT

Graphitic carbons are crucial for large-scale energy storage. With the decline in the traditional high-quality precursors, obtaining carbons from plastic waste is an environmentally friendly approach to support renewable energy storage. Barriers to upcycling waste plastic include its extremely low yield and non-graphitic nanostructure. We demonstrate a novel solution of using Graphene Oxide (GO) as a templating agent to increase yield and obtain high-purity graphitic carbons from plastic waste. GO provides the oxygen required for polymer stabilization while the chemical bonding and sp^2 interactions promote graphitic nanostructure. This work will create a new path for green and efficient graphite manufacturing.

MATERIALS & METHODS

Recycled Plastic

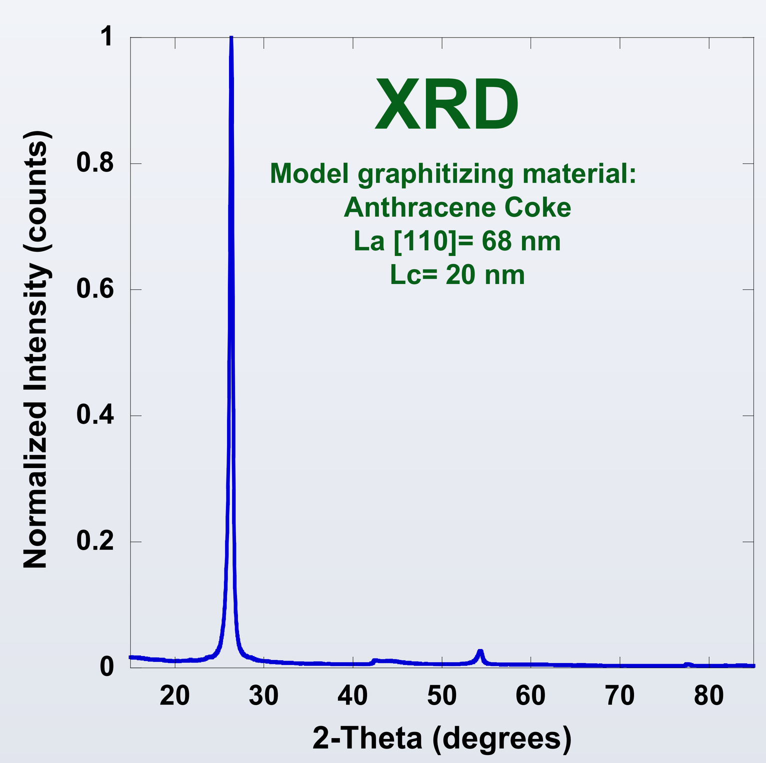


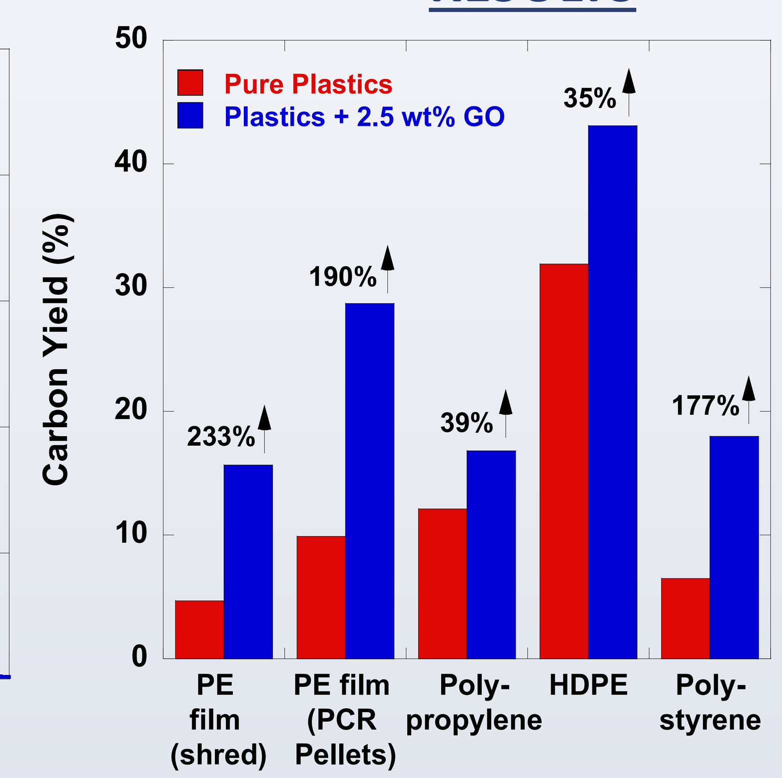


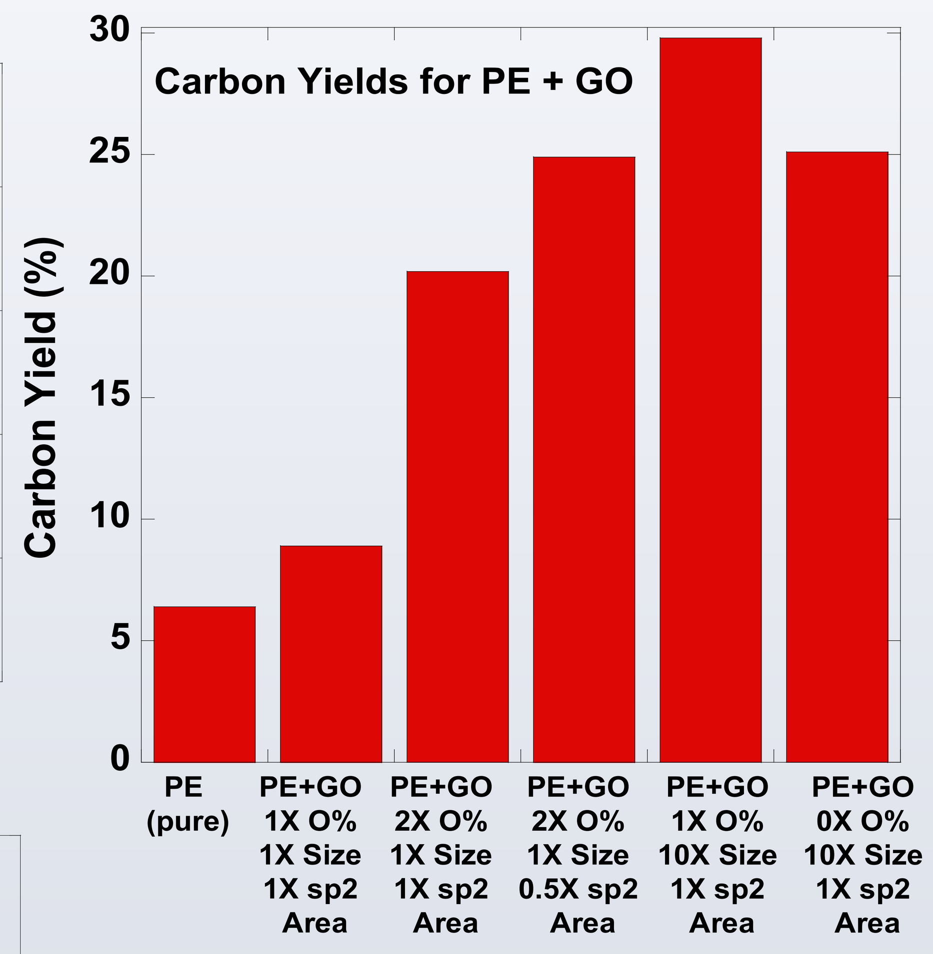
Carbonization at 600°C

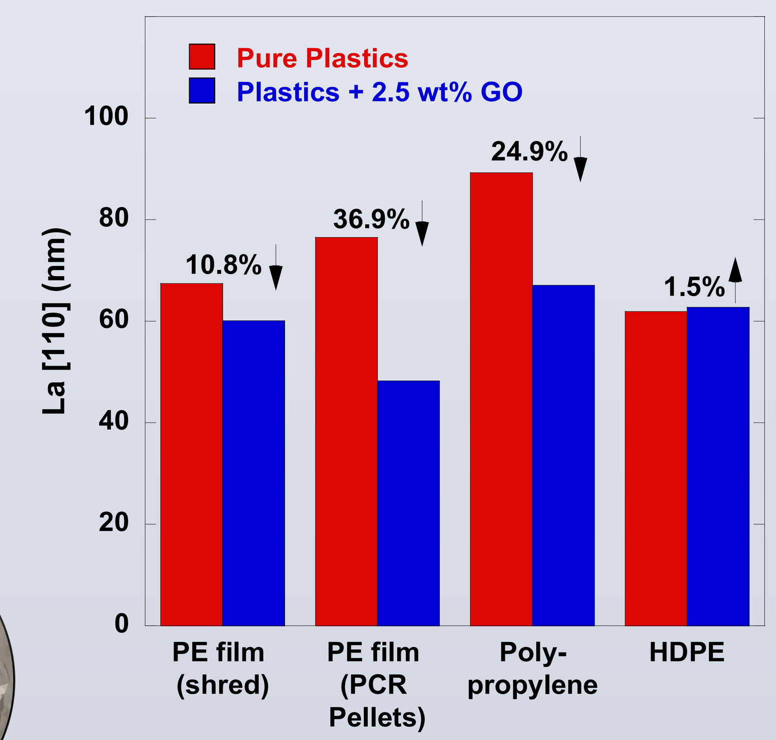
Graphitization at 2500°C

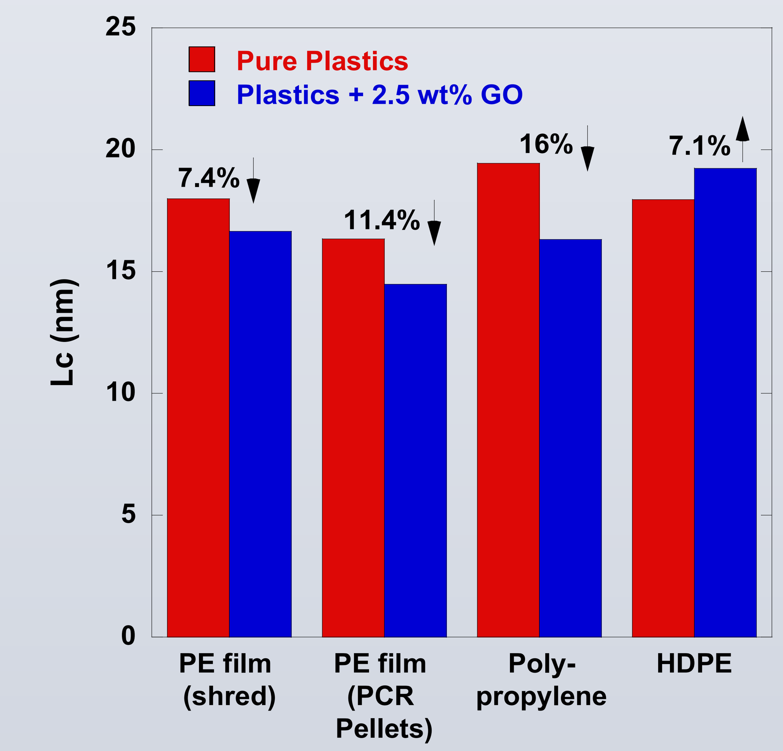
RESULTS

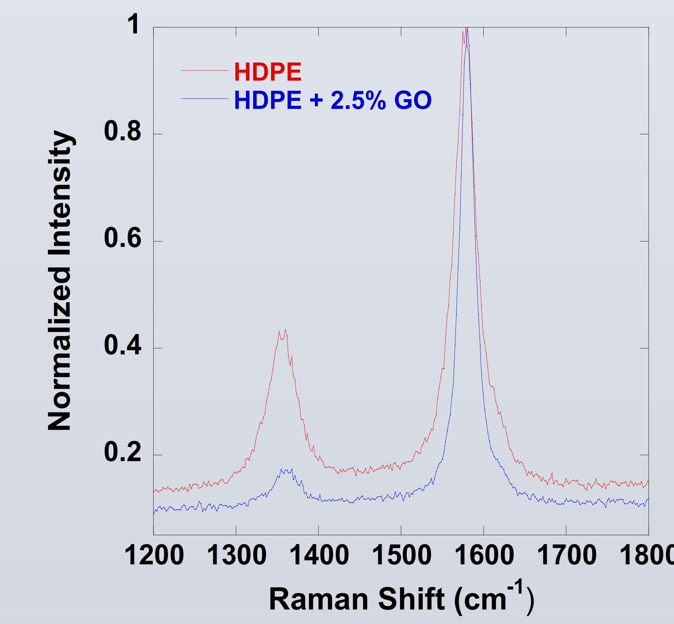


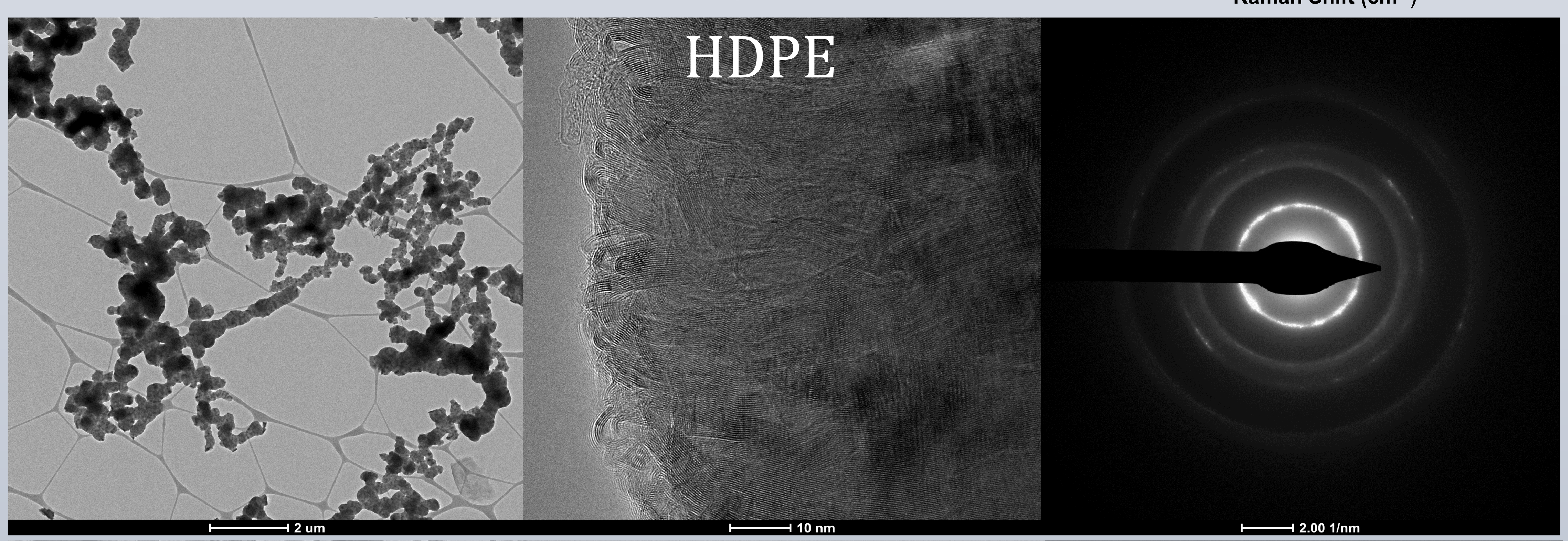


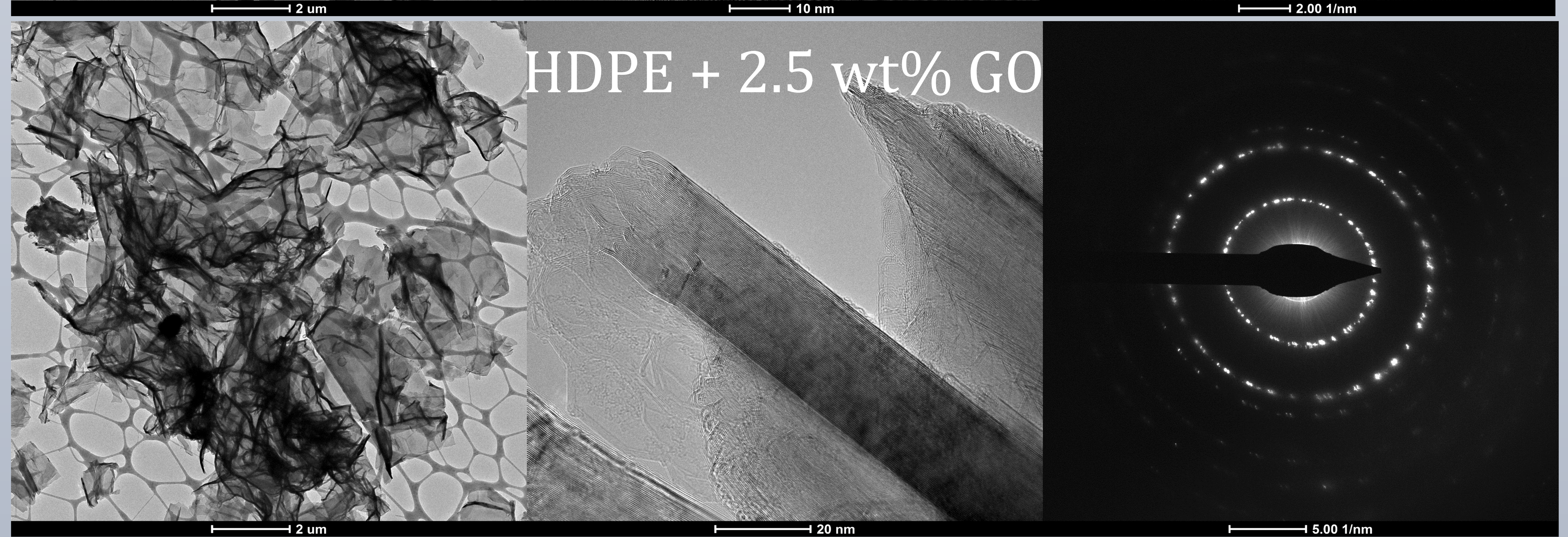












CONCLUSIONS

Pure plastics have extremely low carbon yields as they go through chain unzipping and β-bond scission to produce light gases. Compositing with GO provide excellent stabilization through the radical sites formed by the leaving oxygen groups. The key advantage of GO as additive is that it nets a substantial increase in carbon yields, nearly 250% in some plastics. There is a trade-off between carbon yield and graphitic quality in GO/plastic composites. After graphitization, graphitic quality of GO composites is slightly lower than all pure plastics (except HDPE) potentially because of crosslinking by reactive radical sites on GO which are responsible for the yield increase. Although of relatively lower graphitic quality, GO/plastic composites possess lattice parameters comparable to graphitized anthracene coke. GO can improve yield by 3 main mechanisms: crosslinking by leaving oxygen groups, diffusional confinement of radicals increasing radical combination and stabilization of radicals by the GO π-network. The results from composites with various grades of GO show that oxygen content and lateral size have the most effect on the yield increase. Therefore, crosslinking and diffusional confinement of radicals are the dominant mechanisms in GO/Plastic composites. These highly graphitic composites hold promise as high-quality electrode material in energy storage devices.

FUTURE WORK

- Investigation of changes in carbonization reactions using TGA, DSC and FTIR.
- Electrochemical testing – Li ion battery.
- ReaxFF simulations for the chemistry of GO-plastic reactions.

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The project addresses program goals of (1) use of recycled materials as feedstock in a new recycled content product(s); (2) manufacturing processes research which leads to increased use of an externally sourced recycled feedstock.