STUDY ON UPCYCLING OF POLYSTYRENE PLASTIC WASTE USING RECYCLED OIL INTO GRAPHITE FOR THE ENERGY STORAGE APPLICATION

Tamalika Sarkar, master's student, Department of
Environmental and Biological Sciences, University of Eastern Finland,
e-mail: tsarkar@uef.fi, ORCID: 0009-0009-5260-7203
Anna Lähde, Ph.D., Doc., Professor, Department
of Environmental and Biological Sciences, University of Eastern Finland,
e-mail: anna.lahde@uef.fi, ORCID: 0000-0001-9674-4482
Dmytro Donskyi, Docent NTU KhPI, Ph.D, Visiting Researcher, Department of
Environmental and Biological Sciences, University of Eastern Finland,
e-mail: dmytro.donskyi1@uef.fi, ORCID: 0000-0003-3546-6110
Kirill Murashko, Ph.D., Doc., Postdoctoral researcher, Department of
Environmental and Biological Sciences, University of Eastern Finland, e-mail:
kirill.murashko@uef.fi, ORCID: 0000-0003-0177-8503

The rising global problem of plastic waste management and the increasing demand for renewable energy sources have induced interest in finding sustainable solutions for plastic waste management as well as recovery of the resources. For example, India has constructed over 2,500 kilometers of plastic roads so far and besides all other plastics, polystyrene was utilized in making polystyrene aggregate light weight concrete (Bansal et al., 2023). New methods are needed especially for plastics that are not easily recyclable now. Polystyrene (PS) in plastic group 6 is formed from aromatic hydrocarbon styrene monomers and it is considered hard to recycle plastic.

In this paper we studied the transformation of PS waste to carbonized products. The proposed method involves co-processing PS plastic with cooking waste oil generated in the food industry, particularly from repetitive cooking practices such as frying potatoes, onions, and chips. This approach not only offers a sustainable solution for plastic waste management but also addresses the disposal challenges associated with used cooking oil. Both of these materials belong to the class of renewable resources as the oil is a product of processing plant resources, and plastic is household waste. The standard PS plasticwith markings (6) and rapeseed oil (composition includes 0.7g of saturated fat, 6.2g of monounsaturated fat, and 3.1g of polyunsaturated fat in a 10g serving) were used in the studies.

It has been previously reported that pyrolysis can be applied to convert plastic waste into fuel oil. In this study, PS plastic was subjected to thermal dissolution in oil at temperature range of (120-230) °C without pressure. In this experiment the maximum amount of oil content was 33% of the total mass of polystyrene and the oil mixture. Additionally, possibility of obtaining more condensed plastic structures with solid iron (III) oxide powder and with freshly prepared iron oxide by reaction (1) was investigated. The density of the lump material after joint thermolysis was 0.9-1.16 g/cm^3. Table 1 shows the images of the obtained samples, and their density.

$$4Fe(NO_3)_3{\cdot}9H_2O \rightarrow 2Fe_2O_3+12NO_2+3O_2+36H_2O \quad (1)$$

Table 1: Density of different used samples

Sample	Polystyrene (PS)	Oil	PS + Oil	PS+Oil+ Fe_2O_3 (powder)	PS +Oil+ $Fe(NO_3)_3$ (reaction)
Density, 20°C g/cm^3	0.027	0.843	1.0197	1.1661	0.9013
Image					

The findings of this study contribute to the development of sustainable solutions for both plastic waste management and renewable energy production. Based on the literature, the produced carbon materials shown in Table 1 are suitable for wide use as a binding material for the preparation of a substitute for road binders, fuel briquettes from various components, as well as a binder for briquetting coals for coking, and the option of subsequent carbonization to obtain graphite materials and porous carbon is also being considered.

The yield of the final plastic lump product was 98-99% by weight. Possible losses are associated with experimental processes in oil and plastic upon contact with the walls of the reactor.

Further study of carbonization of samples in an oxygen-free environment under pressure from (6-20) bar and temperature (440-600) °C , a carbon yield of 16-20% wt. achieved. With subsequent graphitization very well structured graphite was obtained .

The structural, compositional, and morphological properties of the created material are investigated using SEM, EDS, TEM, Raman spectroscopy, and TGA techniques acording (Murasko et al.,2024).The electrochemical properties of the graphite are investigated by half-cell testing with metallic lithium counter electrode.

References

1. Bansal, S., Singh Kushwah, S., Garg, A., & Sharma, K. (2023). Utilization of plastic waste in construction industry in India – A review. *Materials Today: Proceedings*. https://doi.org/10.1016/J.MATPR.2023.03.693.

2. Murashko, K. *et al.(*2024).Oxalic acid-assisted preparation of LTO-carbon composite anode material for lithium-ion batteries. Nanotehnology,V.35, N16. https://iopscience.iop.org/article/10.1088/1361-6528/ad1942.