Experimental Analysis of the Solvolysis and Oxidative Liquefaction of the End-of-Life Composite Wastes

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Introduction and motivation

According to the European Union (EU) Waste Framework Directive hierarchy, the disposal of waste without recovery of any form of energetic or material potential should be avoided. Nowadays, one of the biggest challenges of the waste management sector is the incoming supply of large composite wastes (LCWs) from end-of-life wind turbines. The recycling of the LCW should be aimed to recover and reverse as much of the materials and substances back to the loop to not deepen the already environmentally intense cost of its manufacturing. Among the recycling methods for the LCWs, the most popular are mechanical processing and thermochemical (pyrolysis), with numerous highlights on the importance of the development of chemical recycling methods. This paper presents results of the solvolysis (SOL) and oxidative liquefaction (OL) process of epoxy resins and glass fiber reinforced plastics (GRP) that are a major portion of the end-of-life (EoL) wind turbine blade and carbon fiber (CF) and glass fiber (GC) reinforced composites.

Methodology

Oxidative liquefaction

The OL experiments were carried out in batch-type reactor at temperature ranges of 250-350°C, pressure 20-40 bar, residence time of 30-90 minutes, H_2O_2 concentrations of 15-45%, and waste/liquid ratio of 5 to 25%. Wind turbine blades were cut mechanically into small pieces varying in size between 1-2 cm and mixed with water and hydrogen peroxide in suitable proportion according to the experimental conditions. Parr 4650 reactor was used to carry out the experiments at a set temperature and pressure conditions. Nitrogen gas played its role to provide an inert environment and maintain the required pressure inside the reactor. The samples used for the test are presented in Figure 1.

Figure 1. GRP from EoL turbine blades for OL process

Solvolysis

The SOL was carried out in a batch reactor of 1 dm^3 volume. The process temperature was maintained at 190°C at pressureless conditions, with the addition of the 0.0125 mol of triazabicyclodecene (TBD) catalyst in the ethylene glycol solution. The total solvolysis process time was 6 hours.

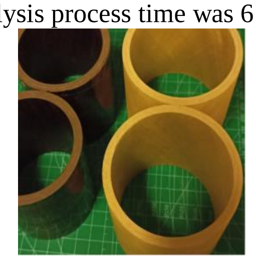

Figure 2. CF (left) and GF (right) composite samples

The materials for the study were two samples of the GF and CF composites provided by B&T Composites (Florina, Greece), presented in Figure 2. The decommissioned composite samples were directed to the solvolysis process without any pretreatment or size reduction.

Results and discussion

Oxidative liquefaction

As the result of the OL process, a large content of resins 48 percent of the total weight has been degraded successfully, but this degradation of resin is dependent upon applied pressure, temperature, the concentration of H_2O_2, and waste to liquid ratio. Experiments showed that out of all these mentioned parameters the resin degradation is highly dependent upon the waste/liquid ratio. Lower waste to liquid ratio results in higher degradation of wind turbine resins that are highly organic in nature and result in the production of volatile fatty acids (VFAs) and some BTXs compounds. Gas chromatography with flame ionization detection (GC-FID) was used to identify the various chemical products in the solution. Identification of various compounds against increasing temperature and increasing retention time in GC-FID can be seen in Figure 3.

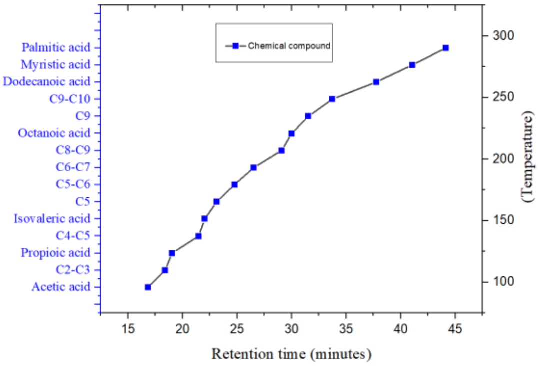

Figure 3. Identification of various chemical compounds against different retention time and temperature

Solvolysis experiments results

After 6 hours of solvolysis processing, the epoxy resin in the polymer matrixes were completely degraded and dissolved. Released GF and CF were separated from the liquid, and dried. Figure 4 presents recovered, separated, and dried GF and CF from the solvolysis process of the composite samples. The average length of the obtained fibers was 50 - 60 mm, with the longest fibers obtained from the GF composite solvolysis reaching 600 - 650 mm.

Figure 4. CF (first 2 pics from left side) and GF composite samples

Conlsuions

Obtained results suggest that the oxidative liquefaction ad solvolysis techniquee have the potential for resin degradation of the LCW and value-added products generation**.**

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