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Opinion

Biochar Use as a Graphite Substitute in an Ultraviolet Radiation Curing Epoxy Ink: Viscosity and Gloss Evaluation

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Opinion

In recent years, the interest in the development of materials with different fillers addition has increased. Among these fillers, carbon-based materials have been increasing attention, mainly due to their ability to improve mechanical, electrical and thermal properties in final composites. Carbon nanotubes are widely used/reported. Nevertheless, its application on a large scale is difficult due to its high cost. In this context, alternative materials with high carbon content and low cost have been studied as possible substitutes, including biochar [1]. Biochar corresponds to the solid fraction resulting from the pyrolysis process and is mainly composed of carbon, oxygen and hydrogen. With an adequate control of the operational conditions, it is possible to adjust and optimize the physical and chemical processes, which determine the properties of the biochar [2]. Biochar has different properties than in natura biomass. The main differences are related to porosity, specific surface area, pore structure and some physicochemical properties. These changes generally increase the reactivity of the material and, therefore, one of the possibilities for using the biochar obtained is as an adsorbent material [3]. Additionally, Poulose et al. [4] and Giorceli et al. [1] reported promising results in the use of biochar as a filler in polymeric matrices. Nevertheless, no studies were identified with the incorporation of biochar as filler in liquid UV curing inks. Therefore, this study aims to use biochar from furniture industry, in a UV radiation curing ink, in order to develop an environmentally correct coating.

For the development of this work, the following materials were used: *Pinus elliottii* sample (from furniture industry waste) for the production of biochar and Sigma-Aldrich synthetic graphite powder (with particle size ≤20μm). For the production of UV radiation curing ink, acrylated epoxy resin, triacrylated trimethylolpropane monomer and 2-hydroxy-2-methyl-1phenyl-propan-1-one photoinitiator were used. Initially, for the production of biochar, the *Pinus elliottii* sample was ground in a knife mill, with the aid of a 0.8mm screen for sample classification. Subsequently, the material resulting from the milling was sieved. For this classification, four sieves were used: 28, 35, 65 and 100 mesh. The sample used for the production of biochar was the fraction with particle size smaller than 147 μm. Afterwards, the initially classified sample was fed into a Sanchis vertical tubular reactor. Approximately 150 grams of sample were fed in each experiment. In total, three experiments were conducted. Additional information about this reactor was reported by Ferreira et al. [5]. The reactor was adjusted to a heating rate of 5 ºC.min^{-1} with a nitrogen (N_2) flow of 100mL.min^{-1}. The final

pyrolysis temperature was programmed for 1050 ºC and the holding time used was one hour. Subsequently, the biochar obtained in the pyrolysis step was ground for one hour in a Red Devil brand ball mill, model 1400, with Yttrium-stabilized zirconium oxide spheres, with diameters from 2.0 to 2.2mm. Regarding to the development of the inks, five samples were produced: reference ink (S0); with 12.5 %wt. of grafite (GS12.5); with 20 %wt. of grafite (GS20); with 12.5 %wt. of biochar (BS12.5); and with 20 %wt. of biochar (BS20). Fixed values were maintained for the photoinitiator (3%) and proportion of acrylated epoxy resin of 60/40 by mass. For the production of the samples, a WEG cowless disperser with 2hp was used. Initially, resin and monomer were added in a container and homogenized for 15 minutes at 1000rpm. Subsequently, graphite and biochar were added with stirring over the resin and monomer mixture and dispersed for 30 minutes at 2300rpm. Finally, the photoinitiator was added with stirring and homogenized for 10 minutes at 1000rpm. Viscosity was measured on a Brookfield Engineering Laboratories Inc, model LVDV-I rotational viscometer and gloss analysis was performed in triplicate according to ASTM D523-08 and using a BYK-Gardner Micro-Tri-Gloss Meter USA. The ink viscosity results indicated that with the addition of fillers, there was an increase in viscosity compared to the ink without filler (S0). Furthermore, graphite when compared to biochar promotes a superior increase in viscosity. Biochar and graphite had a distinct influence on the viscosity of the ink. According to Saidina et al. [6], the graphite shape, in sheets, promotes more significant increases in fluid viscosity when compared to loads with high porosity. According to the authors, particles with high porosity facilitate fluidity on its surface, promoting less change in viscosity. The gloss results indicated that, the gloss of the ink films reduced with the biochar and graphite addition. This reduction was approximately 10, 28, 23 and 30%, for samples BS12.5, BS20, GS12.5 and GS20 respectively, when compared to the reference ink (S0). It was possible to verify that graphite affects the paint gloss more than biochar (samples with the same concentration and different fillers). This phenomenon is related to the deflection of light incident on the surface. Probably the geometry of graphite and biochar has influenced this gloss characteristic. Through the results obtained in this work, it was possible to verify that biochar presented better results compared to graphite when added to ink, both in terms of viscosity and gloss. In addition to the performance observed, the results are considered promising, since it was possible to develop an environmentally correct coating.

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