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Investigation of a Scalable Barrel Atmospheric Plasma Reactor for the Treatment of Polymer Particles

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Abstract

This study reports on the performance of a scalable barrel atmospheric plasma system for the treatment of polymer particles. A novel feature of the barrel system design is the use of a biased electrode, which also acts as the roller for the glass barrel. The plasma is generated using either helium or helium / oxygen gas mixtures. The reactor was used to activate 20 g batches of silicone, polypropylene (PP), acrylonitrile butadiene styrene (ABS) and polyethylene terephthalate (PET) particles, each with diameters in the range 3 to 5 mm. The effect of plasma treatment time and gas flow rate on the water contact angle of the treated polymer particles was examined. The polymer water contact angles decreased from up to 140º to less than 10º after the barrel plasma treatment (polymer dependent). X-ray photoelectron spectroscopy (XPS) analysis is used to monitor the effect of the plasma treatment on both PET and silicone polymer particles. Optical emission spectroscopy (OES) was used as a diagnostic tool to monitor changes in atomic and molecular species intensity with experimental conditions. Emission lines of helium, oxygen and molecular bands of OH, N_2 and N_2^+ were monitored and correlated with their spatial distribution within the plasma chamber. Electrical characterisation studies demonstrated an increase in plasma power with increasing input voltage and helium flow rate. The heating effect of the plasma was monitored using an infrared thermographic camera, the maximum barrel temperature after 30 minutes treatment found to be 29°C. While the current barrel plasma system design can treat 20 g of