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Ethanol vapor addition in a nitrogen dielectric barrier discharge to incorporate nitrogen and oxygen functional groups at low density polyethylene surfaces

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Plasma treatment is frequently used to enhance the surface free energy of low density polyethylene (LDPE). The wettability of LDPE can be significantly increased after plasma treatment in a nitrogen dielectric barrier discharge as evidenced from water contact angle (WCA) measurements. The addition of ethanol vapor to the nitrogen feeding gas gives an extra 85% reduction in WCA compared to a nitrogen alone plasma. The WCA of the LDPE decreases from 103.8° for the untreated sample to 8.5° after a nitrogen/2% ethanol vapor plasma treatment. This reduction is due to the incorporation of both oxygen and nitrogen containing groups at the LDPE surface and due to polymerization of the LDPE surface. This polymerized layer at the surface is very stable and no ageing effects occur as the WCA does not change even after 45 days of ageing.
In order to have a better understanding of the polymerization process, the influence of the power during plasma treatment is further investigated. Both the influence of treatment time at a constant power as the influence of the power itself at a constant energy density is profoundly investigated. From these experiments it can be seen that the power has a significant influence on the wettability results. A minimum power of 10 W is necessary to obtain a WCA of less than 10°. The decrease in WCA is strongly related to the incorporation of nitrogen containing groups, although there is also a high concentration of oxygen containing groups at the surface. The deposition velocity and the surface morphology are also investigated as a function of applied power during the plasma treatment. All this give us a better understanding of the plasma treatment of LDPE using nitrogen/ethanol vapor plasmas.

Keywords
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polymerization
nitrogen and oxygen incorporation