Hydrophobic properties of hydrocarbon films grown by torch-type atmospheric pressure plasma

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Hydrophobicity has attracted interest for applications such as self-cleaning, prevention of snow adherence, reduction of contamination, etc. The maximum water contact angle of a smooth hydrophobic surface is typically about 110°, but with a rough hydrophobic surface, the contact angle can be higher than 150° .

Plasma polymerization is a useful process for depositing thin films from several hydrocarbon precursors. In particular, atmospheric pressure plasma is very useful because it does not require a vacuum chamber and associated pumping system. Plasma processes have been widely studied and developed for preparing several hydrophobic films. In a previous study, where the substrate was textured with an appropriate roughness and the film was produced with atmospheric pressure plasma of CH_4/Ar, which creates an extremely smooth layer on flat surfaces, a water contact angle higher than <150° was realized. This implies that films deposited using atmospheric pressure plasma with hydrocarbon precursors can have superhydrophobicity and an extremely high water contact angle as long as appropriate roughness is provided.

An optimized process is thus needed for deposition of hydrophobic hydrocarbon films under the conditions of atmospheric pressure plasma. When using hydrocarbon precursors with different structures such as benzene, n-hexane, and cyclohexane for plasma polymerization, different surface properties will be obtained due to the differences in the molecular shape and electronic structure of each hydrocarbon precursor. This paper presents the surface characteristics of films deposited with a torch-type atmospheric pressure plasma using C6 hydrocarbon precursors such as benzene, n-hexane, and cyclohexane diluted with Ar gas.

The surface morphologies of the films deposited with n-hexane and cyclohexane were uniformly smooth for all deposition thicknesses, and the typical water contact angle on the films indicating the degree of hydrophobicity, was about 85°. However, the films deposited using benzene had a micro-coarse surface morphology and showed a superhydrophobic property with a water contact angle exceeding 150°. Some trace of oxygen incorporation was shown in all films due to the plasma deposition process in an air ambient. The small amount of oxygenated species did not lead to a decrease of hydrophobicity of the films.