Atmospheric Pressure Chemical Vapour Deposition

New method for producing self-cleaning glass

Photoactive 'self-cleaning' coatings have already found commercial application in products such as bathroom tiles, paving slabs and deodorisers for underground stations. The coatings are made of thin titania (TiO_2) films and will photo-degrade a wide range of substances including bacteria, viruses, herbicides and pesticides. The coatings function by absorbing UV light, causing the formation of an electron and a hole. On migration to the surface, the holes will oxidise organic species and the electrons will reduce oxygen to water. This overall causes the complete mineralization of surface contaminants which can then be readily washed away by rainwater. Pilkington glass have commercialised such a self-cleaning window glass but at present it is prepared by sol-gel routes.

Thin films of titania can be obtained by low pressure chemical vapour deposition CVD, but these routes lead to the incorporation of impurities. Up till now, no atmospheric pressure CVD route had been reported. Work from the lab of Ivan Parkin at UCL now reports such a method (O'Neill *et al, J Mater Chem,* 2003).

Experiments using a horizontal-bed cold-wall atmospheric pressure CVD reactor from 500 – 650°C produced resistant TiO_2 coatings on glass. In various experiments titanium chloride was used with several different alcohols as the oxygen source – all introduced to a mixing chamber *via* hot nitrogen streams.

The films produced consist of stoichiometric single phase TiO_2- the tetragonal anatase phase. Although not the thermodynamically stable phase, this is the desired form for photo-catalysis. The films were shown to have a uniform composition with no chlorine or carbon impurities incorporated. Optical transmittance was comparable to that of plain glass.

After UV irradiation for 30 minutes, contact angles (the angle a droplet of water makes with the surface) of coated glass samples decreased to 1°-10°, showing that the glass becomes super-hydrophilic (i.e. the water entirely wets the coated glass). The change in properties is explained by the conversion of surface Ti^{4+} sites to Ti^{3+} sites upon irradiation. This favours water dissociation at the surface, forming hydroxyl species which increase hydrophilicity. When kept in the dark for 48 hours the contact angle again increases to the pre-irradiated value as oxygen replaces the surface hydroxyls. However, if stored in natural light, the coated glass keeps its hydrophilicity.

Photocatalytic activity was assessed by testing the coatings ability to destroy an overlayer of stearic when irradiated with UV light. All films showed good photocatalytic response – completely destroying the stearic acid after 30 minutes of irradiation.

O'Neill and co-workers have shown that a simple and fast atmospheric pressure CVD method can be used to create uniform anatase coatings on glass. The coatings have excellent surface coverage, adhesion, purity and are free of pinholes. This is the first reported atmospheric pressure CVD film functioning as an active photocatalyst. The method is inexpensive and the combination of low contact angle and extremely fast photocatalytic response means that the TiO_2 coatings produced are suitable for self-cleaning applications. The method described may lead to a superior process to that presently used commercially.

Atmospheric pressure chemical vapour deposition of titanium dioxide coatings on glass. S A O'Neill, I Parkin, R J H Clark, A Mills & N Elliott *J Mater Chem,* 2003, **13**, 1, 56