How do nano-silica and nano-alumina improve the scratch resistance of clear coatings?

Conventional method of improving mechanical properties of coatings is based on enhancing the degree of cross-linking in the film. This is achieved by altering the nature/functionality of the resin, choice of the cross-linker, the catalyst and the stoichiometric ratio. The higher the cross linking density, the higher the hardness and better is the scratch resistance. However nanotechnology has opened up a new avenue for enhancing the surface hardness.

This concept involves incorporation of small percentage of nano-scale alumina or silica in the coating. Alumina and silica are hard minerals with Mohs hardness 9 & 7 respectively. These materials are available as pre-dispersed additives in the liquid form for easy incorporation. The nanoparticles present in the surface layer of the film enhance the scratch hardness. This protects the film against marring, crocking, wearing and mild abrasions. The coatings are thus able to retain their gloss longer under the real life service conditions for automotives, wood furniture, parquet flooring and UV cured lacquers.

When the particle size is in the conventional micron range, these metal oxides have a mattening effect on the coatings due to the scattering of light. When these particles are reduced to nanoscale of 20~ 40nm, they do not scatter light and become transparent like the clear resin film. Main contribution from the nanosize is the transparency to the visible light which helps retain the film clarity. Silica although not quite as hard as alumina, has lower refractive index closer to the resins and thus preserves the transparency better than alumina. However alumina can be used at a lower dosage (1~2 %) compared to silica to attain the same level of surface hardness. Surface modified nanosilica is also available for better mar resistance.

The other advantage of this approach is the non-interference in the chemical cross-linking reactions leaving the curing speed (and pot-life in case of 2K systems) largely unaffected

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