Study on Surface Fracture Behavior of Acrylic Hard Coatings under Scratch Loading

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Surface fracture behavior of polymeric coatings was studied using a progressive load scratch test according to ISO 19252. Acrylic coatings, i.e. Trimethylolpropane triacrylate (TMPTA), pentaerythriol triacrylate (PETA) on Poly (methyl methacrylate) (PMMA) substrate were chosen as studied models. Effects of material characteristics and coating composition were investigated. The coatings with and without soft base layer were prepared to demonstrate the soft base layer effect. It was found that the presence of soft base layer resulted in excellent resistance to crack initiation and substrate exposure. Moreover, crack extension was slowed down when the soft base layer was incorporated into the coating systems. An increase of soft base layer thickness was also able to further enhance the scratch resistance and effectively retarded crack extension. In addition, the influence of soft base layer on mar and abrasion behavior was studied. Mar and abrasion behavior were strongly influenced by the soft base layer despite using different top layers. The SCOF and surface roughness significantly reduced with increasing the soft base layer thickness. To further verify the soft base layer effect on scratch behavior, soft base layer with different hardness was prepared by incorporating diacrylate monomer. The scratch test result was greatly support the above results. The introduction of soft base layer caused a great improvement on scratch resistance. However, it seemed that there is an optimum hardness of soft base layer to achieve excellent scratch resistance. Additionally, influence of surface segregation of multi-funtional methylmethacrylate-POSS (MA_8POSS) on surface physical properties of PETA coating was demonstrated. The results indicated that the scratch resistance was correlated with MA_8POSS segregation behavior. Scratch resistance was deteriorated at MA_8POSS loadings higher than 20 wt %. This because MA_8POSS was fully covered the outermost surface and the degree of conversion was significantly regulated due to the huge steric hindrance of MA_8POSS.

This work indicated that surface fracture behavior of acrylic coating under scratch loading was strongly affected by the presence of the soft base layer. The localized stress at the top surface could be minimized when the soft base layer was introduced to the coating system. Moreover, it was found that surface segregation was one of the influencing factors for scratch behavior.