ABSTRACT

Hydrophilic self-cleaning surface fabricated using photo-catalyst as base material is a thrust area in the present decade. Due to the presence of photo-catalyst, the organic pollutants come in contact with the surface are degraded in presence of photons with suitable wavelength by the process called photo-catalysis. Also, the self-cleaning surfaces are used as hygienic coating since the reactive oxygen species generated by the photo-catalysts can mitigate wide range of bacterial strains. However, research related to paint like polymer matrix impregnated with photo-catalytic pigment is rare. Therefore, photo-catalyst suspended paint is very much essential to gain knowledge in the field of smart coatings and is chosen as our research topic. In the present research work, the self-cleaning paint like coatings are fabricated by impregnating semiconductor nano-photo-catalyst in the alkyd resin matrix along with other paint forming additives via high energy ball milling technique. The photo-catalytic pigment present in the surface of the coating degrades the organic pollutants when comes in contact. Further, they also act as hygienic coating since the photo-catalyst present in the coating effectively kills wide range of pathogenic bacteria especially found in hospital environment, garbage, kitchen sinks, etc. Since the prepared coating system act as paint, it can be coated over any substrate with ease. Also, the self-cleaning coating applied over building structures can be used as an environmental remediation technique since they degrade the organic pollutants into harmless species. It has been understood that the degradation efficiency of the photo-catalytic pigment plays major role in the self-cleaning surface. Therefore, attempts have been made to improve the degradation efficiency of semi-conductor photo-catalytic nanoparticles by blending of two semiconductor nanoparticles or by doping suitable impurities or
morphological alteration. The semiconductor photo-catalysts such as zinc oxide nanoparticles (ZnO Nps) and magnesium oxide nanoparticles (MgO Nps) are chosen as pigment for the fabrication of self-cleaning coating. The performance of ZnO Nps is improved by mixing ZnO and SnO₂ (MZOTO) in various percentages and doping with Ag (SDZO). In the case of MgO Nps, the morphological alteration signifies the formation of nanopores towards the photo-catalytic activity. The prepared nanoparticles are characterized by studying their structural, elemental, morphological and optical properties. Since the prepared nanoparticles are used as self-cleaning pigment for the coating system, their photo-catalytic performances are evaluated against known quantity of crystal violet dye as model pollutant under the influence of sunlight. To quantitatively compare the photo-catalytic activity, the degradation rates of the reaction processes by different nanoparticles are estimated using Langmuir–Hinshelwood relation. The rate constants are evaluated as 0.0257 min⁻¹, 0.10168 min⁻¹, 0.1267 min⁻¹, and 0.05941 min⁻¹ for ZnO Nps, MZOTO-2 (mixing ZnO and SnO₂ in the ratio 1:0.5), 1% SDZO Nps (1% Ag doped ZnO) and MgO Nps respectively. From the results, it is clear that the photo-catalytic performance of 1% SDZO Nps is higher substantiating the effectiveness of doping Ag on the photo-catalytic activity of ZnO. Also, from the free radical trapping experiments, it is identified that the reactive oxygen species such as hydroxyl radicals, super-oxide anions and photon induced holes generated by 1% SDZO Nps are responsible for the effective mitigation of crystal violet molecule than other nanoparticles where they generate only super-oxide anions and photon induced holes. Further, the photo-catalytic pigments impregnated alkyd resin coating is prepared by mixing with required additives in adequate percentages through ball milling technique. After preparing the respective paints, their properties such as volatile organic compounds, solid content, and drying time are estimated for all the specimens. After complete drying of the coating, self-
cleaning activity of the coating is estimated against crystal violet molecules. The known quantity of crystal violet molecules are made to adhere over the obtained coating, are placed under sunlight and noted the time required for the complete degradation of crystal violet. From the obtained values, it is clear that the self-cleaning behaviour is higher in the case of 1% SDZO Nps impregnated coating which clearly coincides with the photo-catalytic behaviour of the pigment. Furthermore, the disinfectant property of some of the photo-catalysts and the respective coatings are performed to elucidate its bactericidal activity to be used as hygienic coating.

All the results obtained so far confirms the self-cleaning activity influenced by the photo-catalytic degradation of the organic pollutants by the prepared semi-conductor photo-catalyst nanoparticles as in native form and in the form of coating. Photo-catalytic activities of various particles against the degradation of crystal violet in sunlight are compared with the commercial P25 TiO$_2$ Nps. Mitigation of crystal violet by the photo-catalyst in terms of morphology, doping, coupling, etc. are investigated. Further, the self-cleaning effect of the coatings prepared using semi-conductor photo-catalyst as pigment is also compared. From the inferred data, it is found that the 1% SDZO Nps impregnated coating displays better degradation rate than that of commercially available photo-catalyst and tends to be a better choice as the photo-catalytic pigment for self-cleaning applications.