nanomaterials

Editorial

Development of Nanocomposite Coatings

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Special Issue in the Development of Nanocomposite Coatings in nanomaterials was setup with the aim to provide an opportunity to showcase the latest developments within the theme of this special issue. It therefore welcomed research articles and reviews papers, by invitation only, within the context of nanocomposite coatings for possible publications. There are wide ranging major applications of nanocomposite coatings for example corrosion, tribology, machine elements, components, complex interacting systems, and fluid flow especially within the context of cavitation. We have been witnessing increased application needs to address key global and industrial challenges including energy efficiency, reliability, sustainability and durability of systems and machines. These components and systems are often deployed in harsh operating environments and conditions, for example, very high and subzero temperatures, extreme pressures, very high loading, exposure to corrosive environment, and starved lubrication. To solve these issues, novel and innovative approaches are needed. These solutions include optimisation of surfaces and interfaces through surface modifications and coatings. Development and applications of nanocoatings and nanocomposite coatings are relatively new and developments in this area are underway.

Design and engineering processes and techniques which are focused on the development of nanocomposite coatings have provided significant opportunities to address the above mentioned key issues. In turn researchers around the globe have been actively engaged in studying several types of nanocomposites for developing durable and energy efficient coatings. This offers several academic and industrial benefits.

Experimental results and numerical models of alumina, silicon carbide, zirconia and graphene nanocomposite coatings have been previously presented and published. These coatings have been experimentally investigated by employing a micro-friction reciprocating bench top test machine. Test conditions, test and load configurations with three types of experimental medium; uncontaminated oil, contaminated oil with 5% wt. sea water and contaminated sea salt 5% wt. and water 10% wt., at the interface are provided and are discussed [1-4].

Cathodic blistering model Khan-Nazir I has been developed and reported in [5] and is provided below in Eq. 1.

$$\frac{6(1-v_c^2)}{E_c h^3}\left[M_c^2+\left(0.2(1+v_c)\sqrt{\frac{1}{0.2(1+v_c)+0.2(1-v_c^2)}}\left(\frac{p}{p_{cr}}-1\right)\right)^2\right] \qquad (1)$$

Wherev_c = Poisson's ratio of coating; E_c = Elastic modulus of coating; h = thin film, coating thickness; Mc = blistering induced film-substrate system bending moment; *p* = blister pressure; p_{cr} = critical pressure [6].

Coating failure model Khan-Nazir II has been extended to nano composite coating failure subject to wear-corrosion as mechano-wear model [8] as shown in Eq. 2.

$$\overleftrightarrow{J} = \frac{F\rho}{KA_s\, t}\left(V - \left(K_v \sum W\right) - S\right) \quad (2)$$

Where $\overleftrightarrow{J}$ = corrosion current density; F = Faraday's constant; ϱ = coating density; K = specimen material's electrochemical equivalent; A_s = area of the specimen; t = time; V= wear-corrosion volume loss; K_v= wear rate; W = Archard factor density; S = synergistic factor [8]. A further development by inclusion of lubrication modelling with wear-corrosion and mechano-wear equations was performed to investigate the influences of intrinsic microstructural properties of nanocomposite coatings for instance porosity and surface stresses on the Coefficient of Friction (CoF) [7].

$$\mu = \left(u\, \eta_o \pi \left(4PR/\pi L\left((1 - v_1^2)/E_1 + (1 - v_2^2)/E_2\right)\right)^2\right)/(Ph_o il\infty) \quad (3)$$

Where coefficient of friction is denoted by μ; while the normal force is represented by P, and the radius of steel ball is taken as R; L ball-coating contact is the axial length; Y_1 and E_1 are the Poison ratio and Young's moduli of coating while Y_2 and E_2 are the Poison ratio and Young's moduli of substrate respectively; η_0 is the viscosity of bulk lubricant; $h_{oil\infty}$ is the remaining thickness of the oil in vicinity of the asperity contact.

Special attention is paid in this issue to experimental methods for analysing the corrosion degradation of nanocomposite coatings. For example, two major types of coating deteriorations are: (i) cathodic delamination and (ii) cathodic blistering including wear-corrosion dilapidation, subject to wear and corrosive environments. These failure mechanisms initiate and propagate from pre-existing defects which exist in coatings, in turn this facilitates corrosive species diffusion from an external electrolyte [8]. When cathodic delamination is considered, the parting of the film is mainly driven by the cathodic reaction in a localised corrosion cell [9].

Some important improvements suggested in ref. [10] can be incorporated in the existing modelling techniques to improve the failure predictions of nanocomposite coatings for example: Micro-cracks effects [11, 12, 13], multi-layer films effects [14], potential distribution within delaminating region [15] and the nature of film-substrate bonding [16].

Micro and nano-sensors development for motioning the degradation rate of nanocomposite coating has always been an important research area. Some vital research in sensing technology is mentioned herein [17, 18, 19].

Latest research has synthesised magnetic chitosan nanocomposite by employing an established ultrafast US irradiation informed strategy which presented good crystallinity, high Ms ranging and high surface area [20]. Likewise, Chitosan-TiO_2 coatings which have various concentrations of TiO_2NPs have been produced, and their thermal, antimicrobial and physicochemical characteristics were methodically categorised [21]. In another research fabrication of nano structured Co-Pb composite anodes was achieved by employing ARB. Results of this investigation has demonstrated that ARB process enhances mechanical attributes of Co-Pb anodes [22]. It is also known that one of the novel surface treatment processes to develop nanocoating is Plasma Electrolytic Oxidation (PEO). The PEO process causes transformations of microstructure within coatings, a reduction of residual stresses within coatings takes place with enhanced coating homogeneity [23].

Nb alloying layer over TC4 substrate was developed by various HCPEB irradiation pulses which led to improved surface performance [24]. Likewise, WN/MeN (Me = Cr, Zr, Mo, Nb) nanocomposite multi-layered coatings were deposited by CA-PVD, this was studied by analysing the microstructures, wear behavior, friction performance, and mechanical properties of WN based multilayers [25]. Another research work demonstrates a one-pot, hydrothermal, template-free method for the successful synthesis of α-Fe_2O_3 (hematite) and Fe_3O_4 (magnetite) [26].

It can be seen that the recent developments in nanocomposite coatings, real-time monitoring, failure predictions modelling, and future systems have been reported in this Special Issue. Therefore, it is highly recommended that researchers, scientists, academics and industry professional read this Special Issue for enhancing future design and development of nanocomposite coatings. We will look forward to your work and contributions to this journal within but not limited to the impactful and fascinating theme of this Special Issue in the near future.

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