CORROSION PROTECTION OF STAINLESS STEEL 316L BY INCORPORATING ZINC OXIDE-(POLY(3,4-ETHYLENEDIOXYTHIOPHENE)-POLY(STYRENESULFONATE), PEDOT:PSS) HYBRID NANOCOMPOSITE IN EPOXY BASED COATING FOR MARINE APPLICATION

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Stainless steel 316L is extensively used in high performance application due to its good mechanical strength and resistance towards corrosion. However, this type of steel is still tends to undergo pitting and crevice corrosion when exposed to aggressive environment such as marine environment. In this study, a new coating material is formulated to control corrosion by introducing zinc oxide (ZnO) and (poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate), PEDOT:PSS) hybrid nanocomposite into epoxy resin based coating. The physiochemical properties of formulated coating and the effect of varied weight percentage (wt.%) of hybrid nanocomposite with immersion time on coating performance is studied. To achieve these objectives, 1 to 5 wt.% ZnO-PEDOT:PSS is mixed and dispersed in epoxy based coating and coated on 316L substrates using brush coating technique. The samples are immersed in real environment for 60 days. The Fourier Transform Infrared spectroscopy (FTIR), Field Emission Scanning Electron Microscope/Energy-Dispersive X-ray spectroscopy (FESEM/EDX), Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD) and Thermo-Gravimetric Analysis (TGA) analysis showed good compatibility and stability between ZnO and PEDOT:PSS in epoxy based coating while maintained amorphous state of epoxy coating. Based on potentiodynamic polarisation and Electrochemical Impedance

Spectroscopy (EIS) analysis, addition of 1 to 2 wt.% ZnO-PEDOT:PSS shows an increment on corrosion protection values. Incorporation of 2 wt.% ZnO-PEDOT:PSS provided optimum protection value of corrosion current density, i_{corr}, positive shifting of corrosion potential, E_{corr}, corrosion rate, CR, charge transfer resistance, R_{ct} and double layer capacitance, C_{dl} values as 2.07 x10^{-7} A•cm^{-2}, -0.2646 V, 0.0022 mm/yr, 2.84 x10^{5} Ω•cm^{2} and 5.73 x10^{-5} F; respectively. Addition of 3 to 5 wt.% ZnO-PEDOT:PSS showed the decrement of parameters values. At 30 days immersion duration, samples with 2 wt.% ZnO-PEDOT:PSS provides optimum anti-corrosive behaviour. The entire samples regardless wt.% had achieved passivation state after 45 days of immersion duration. In conclusion, addition of 2 wt.% ZnO-PEDOT:PSS in epoxy based coating able to provide optimum anti-corrosive properties and addition of 3 to 5 wt.% ZnO-PEDOT:PSS enhanced corrosion activity of stainless steel 316L due to nature properties and limitation of PEDOT:PSS.

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PERLINDUNGAN KAKISAN PADA KELULI TAHAN KARAT 316L MENGGUNAKAN ZINK OKSIDA-(POLI(3,4-ETILENADIOKSITIOFENA)-POLI(STIRENASULFONAT), PEDOT:PSS) KOMPOSIT-NANO HIBRID DALAM SALUTAN BERASASKAN EPOKSI UNTUK APLIKASI MARIN

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Keluli tahan karat 316L digunakan secara meluas dalam aplikasi berprestasi tinggi berdasarkan kekuatan mekanikal dan rintangan kepada kakisan. Walau bagaimanapun, keluli jenis ini masih berpotensi untuk mengalami kakisan bopeng dan kakisan rekahan apabila terdedah pada persekitaran agresif seperti persekitaran marin. Dalam kajian ini, satu bahan salutan baru diformulasikan bagi mengawal kakisan dengan menggunakan zink oksida (ZnO) dan (poli(3,4- etilenadioksitiofena)-poli(stirenasulfonat), PEDOT:PSS) nanokomposit hibrid ke dalam salutan berasaskan epoksi resin. Ciri-ciri fisiokimia salutan yang diformulasi dan kesan pelbagai peratusan berat (*wt.%*) nanokomposit hibrid terhadap masa rendaman kepada prestasti salutan dikaji. Bagi mencapai objektif-objektif ini, 1 hingga 5 *wt.%* ZnO- PEDOT:PSS dicampurkan dan di sebarkan dalam salutan berasaskan epoksi dan disalutkan pada substrat 316L menggunakan teknik salutan dengan berus. Sampel-sampel direndamkan pada persekitaran sebenar untuk 60 hari. Analisis spektroskopi transformasi fourier inframerah (FTIR), mikroskop imbasan electron dengan percambahan medan/penyerakan tenaga sinar-X (FESEM/EDX), mikroskopi electron transmisi (TEM), pembelauan sinar-X (XRD) dan analisis termogravimetri (TGA) menunjukkan keserasian dan kestabilan di antara ZnO dan PEDOT:PSS dalam salutan berasaskan epoksi dengan mengekalkan keadaan amorf salutan epoksi. Berdasarkan, berdasarkan kepada polarisasi potensiodinamik dan

spektroskopi impedans elektrokimia (EIS) analisis, penambahan 1 sehingga 2 *wt.%* menunjukkan peningkatan pada nilai perlindungan kakisan. Penambahan 2 *wt.%* ZnO-PEDOT:PSS menghasilkan nilai perlindungan kakisan yang optimum iaitu densiti arus kakisan, i_{corr}, anjakan positif pada keupayaan kakisan, E_{corr}, kadar kakisan, CR , rintangan aliran cas, R_{ct} dan kapasitans dwilapisan, C_{dl}, iaitu 2.07 x10^{-7} A•cm^{-2}, -0.2646 V, 0.0022 mm/yr, 2.84 x10^{5} Ω•cm^{2} and 5.73 x10^{-5} F; setiap satu. Penambahan 3 sehingga 5 *wt.%* ZnO-PEDOT:PSS menunjukkan penurunan nilai-nilai parameter. Pada 30 hari rendaman, sampel mengandungi 2 *wt.%* ZnO-PEDOT:PSS menghasilkan ciri-ciri anti-kakisan yang optimum. Kesemua sampel tanpa mengira *wt.%* telah mencapai keadaan pasif pada 45 hari tempoh rendaman. Kesimpulannya, penambahan 2 *wt.%* ZnO-PEDOT:PSS mampu menghasilkan ciri-ciri anti-kakisan yang optimum dan penambahan 3 sehingga 5 *wt.%* ZnO-PEDOT:PSS meningkatkan aktiviti kakisan pada keluli tahan karat 316L disebabkan oleh ciri-ciri semula jadi dan kekangan PEDOT:PSS.