Characterization and microhardness of electrodeposited Ni–W–P coatings obtained from gluconate bath

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Electrodeposited Ni–W–P alloy coatings are considered as one of the potential replacements for conventional hard chromium. In this work, Ni–W–P coatings with different phosphorous concentrations have been prepared by direct current (DC) and pulse current (PC) electrodeposition methods using gluconate bath for the first time. These coatings were characterized by XRD, FESEM, AFM, DSC and XPS techniques. Thicknesses and current efficiencies are found to be more in DC plated coatings compared to PC plated coatings. EDX analysis confirms the presence of nickel, tungsten and phosphorous in the deposits and amount of P is observed to be more in PC coatings compared to DC coatings. XRD studies demonstrate that the coatings are nanocrystalline in nature which on heat treatment show the formation of Ni_3P phase. FESEM demonstrates that DC Ni–W–P alloy deposits show fine nodules, whereas all PC Ni–W–P coatings have fine grains with smooth morphology. Increase in roughness with time and increase in P content is observed in AFM roughness measurement. DSC of DC coatings are characterized by two peaks (250 and 360 °C) while pulse plated exhibits only the high temperature peak. Ni is in both +2 and metallic states in all coatings, whereas W^0 and W^{6+} species are observed in all coatings. Amount of oxidized Ni is more in PC coatings in comparison with DC coatings. On the other hand, P is in $P^{\delta-}$ and P^{5+} states in these coatings. PC coatings show higher microhardness and it increases with heat treatment.

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