Corrosion behaviour of dissimilar metal/metal joints including reinforcing additives

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The evaluation of the corrosion behavior of dissimilar metal/metal joints and a comparison with the parent metal alloys is demonstrated in the present study. The metal/matrix joints reinforced with nanoparticles are produced via friction stir welding (FSW). Friction stir welding is a solid-state joining process that uses a third body tool to join two facing surfaces and has been employed in aerospace, rail, automotive and marine industries. In the present work, dissimilar friction stir welds were produced in plates of AA 6082-T6 and AA 5083-H111 aluminum alloys using cerium molybdate (CeMo) nanocontainers, titanium-carbon (TiC) nanoparticles and carbon nanotubes (CNTs) additives as reinforcing materials (table 1). The process parameters were optimized in order to achieve non-defective welds with and without the addition of reinforcing materials. Radical polymerization as well as the sol-gel method were used for the synthesis of CeMo nanocontainers. The produced CeMo nanocontainers were then loaded with the corrosion inhibitor 2-mercaptobenzothiazole (MBT). The use of the loaded CeMo nanocontainers as additives was accomplished via their incorporation into hybrid organic-inorganic coatings that were applied on the joining faces of the aluminium plates prior to the welding process. In order to incorporate the reinforcing fillers, half volume grooves were machined at the joining faces of the plates. The morphology of the produced nanocontainers, nanoparticles and nanotubes was determined by scanning electron microscopy (SEM) and transmission electron microscopy (TEM); their elemental analysis was accomplished via energy dispersive x-ray spectroscopy (EDS). The produced TiC nanoparticles had an average size of 150-200 nm (Fig. 1a), the diameter of the synthesized CeMo nanocontainers was 230 ± 20 nm (Fig. 1b) and the external diameter of the fabricated CNTs ranged between 60 nm and 100 nm while their length was roughly 5 μm (Fig. 1c). Figure 2 demonstrates the SEM images of the cross-section of the Stir Welded metal/metal joints reinforced with CNTs (SW-CNTs) and with TiC (SW-TiC) at the welded nugget (WN), where the dark areas are attributed to the incorporation of the additives due to the presence of carbon element. The corrosion resistance of the samples (with and without additives) was studied by electrochemical impedance spectroscopy (EIS), linear polarization resistance (LPR) and linear sweep voltammetry (LSV). Corrosion test process includes the exposure of the panels to a 5 mM NaCl solution prepared with distilled water. The Bode plots of the EIS spectra obtained for samples after 24 hours of exposure to corrosive environment are demonstrated in Fig. 3; as presented, the Stir Welded metal/metal joint including CeMo (SW-CeMo) has the highest absolute total impedance value compared to the samples with TiC and CNTs or without additives. Regarding the presence of TiC and CNTs into the composite, it is observed that they do not impart additional corrosion protection to the final product compared with the SW-blank sample, as their absolute total impedance values are almost similar. Thua, this result clearly denotes that the incorporation of CeMo loaded nanocontainers during the FSW process enhances the anticorrosive properties of the final product.

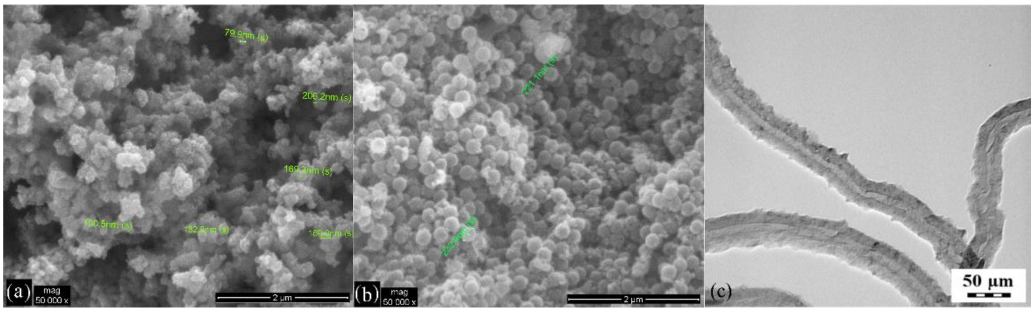

Figure 1: SEM images of TiC nanoparticles (a), CeMo nanocontainers (b); TEM image of carbon nanotubes (c).

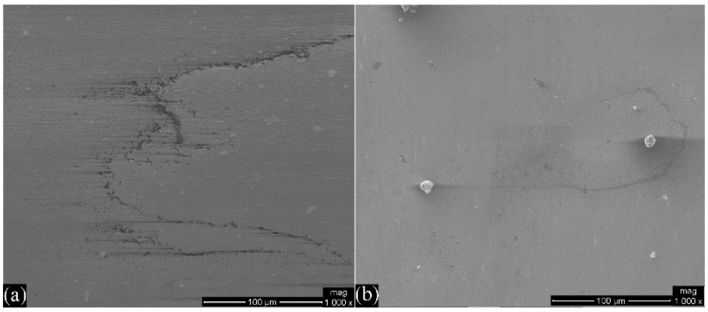

Figure 2: SEM images of the cross-section of SW-CNTs and SW-TiC at the welded nugget.

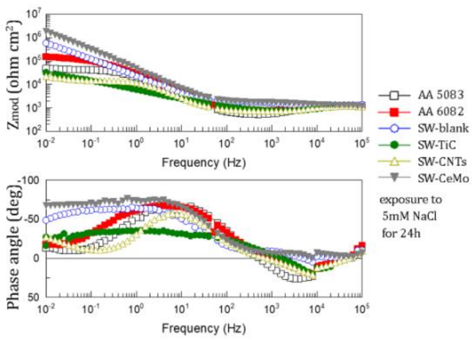

Figure 3: The Bode plots of the EIS spectra obtained for samples after 24 hours of exposure to corrosive environment.

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