

Molten carbonate salts doped with nanoparticles for corrosion mitigation in CSP/CST technologies

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Introduction

Nanosalts are dispersions of nanoparticles in pure or mixed molten salts. It has been shown that some of the thermophysical properties of the salts are enhanced in relation to the base molten, particularly their thermal conductivity and heat capacity [1, 2]. This result, makes them a promising solution to enhance the power generation efficiency of next generation concentrated solar power (CSP) technology. However, the use of these nanosalts in a CSP plant faces many challenges [2], namely their behavior in contact with structural materials that must be addressed to provide the choice of cost-effective steels. This work aims to present the results of the study of the corrosion of AISI 430 stainless steel in contact with molten LiNaK carbonate salts doped with MgO and SiO₂ nanoparticles.

Methodology and results

Three mixtures of molten salts were prepared, one only with the eutectic mixture of lithium, sodium and potassium carbonate salts (32.1:33.4:34.5 m/m), and two new mixtures of these molten salts, doped with 1% MgO nanoparticles (99% purity, 20 nm); and 1% SiO₂ nanoparticles (99.5% purity, 10~20 nm, non-porous) from SkySpring Nanomaterials, were homogenized with the eutectic mixture in a mechanical mill for 5 min in a clean room. The undoped mixture also contains magnesium as an impurity.

The corrosion tests were carried out in a muffle furnace at 650 °C the AISI 430 steel being in direct contact with each of the mixtures for 24, 240 and 1000 hours, under static conditions and atmospheric air.

As demonstrated in Figure 1, the corrosion rate of the mixture with 1% SiO₂ exhibits a higher rate over time in comparison to the other two salt mixtures, with this difference being more pronounced in the initial times. With regard to the mixture with MgO, the corrosion rate tends to stabilize after 240h at a lower rate than the mixture without doping (221 ± 4 vs 326 ± 52 $\mu\text{m}/\text{year}$ at 1000h).

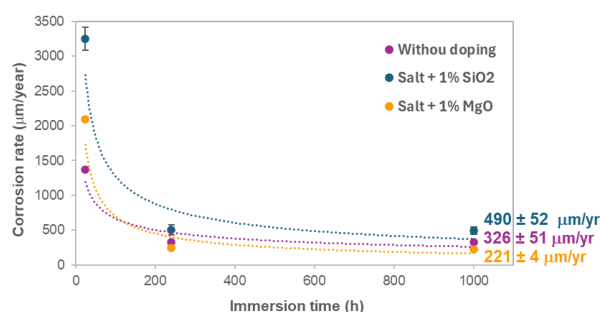


Fig.1: Corrosion rate of AISI 430 immersed in different mixtures LiNaK carbonate salt at 650 °C.

SEM surface images (Fig. 2) demonstrate that the morphological structures of the oxides formed after 1000 hours are different, depending on the type of nanoparticles used on doping the salt. However, by analyzing the respective XRD diffractograms (at 1000h), the oxides identified were the same ($\text{Li}_5\text{Fe}_5\text{O}_8$, LiFeO_2 and MgO).

At 240 hours, in the case of the mixture without doping and with 1% MgO , the formation of LiCrO_2 was also observed, in addition to $\text{Li}_5\text{Fe}_5\text{O}_8$, LiFeO_2 and MgO .

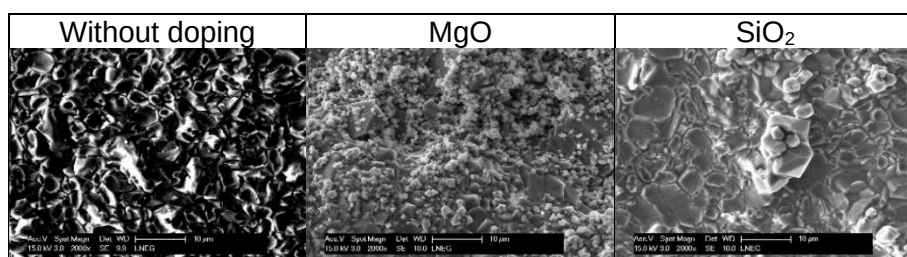


Fig.2: SEM images obtained with SE detector of the oxide scales formed on AISI 430 after immersion different mixture LiNaK carbonate salt at 650 °C after 1000 h.

These results show that magnesium oxide nanoparticles appear to have a significant impact by reducing the corrosion rate of AISI 430 stainless steel (from 326 to 221 with 1% MgO nanoparticles), which is not the case for silica.

Acknowledgments

The authors greatly appreciated the financial support FCT - Fundação para a Ciência e a Tecnologia, I.P., from project NEWS4CSP (2022.05021.PTDC) (<https://doi.org/10.54499/2022.05021.PTDC>).

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