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Accelerated aging tests to selective solar absorber coatings for low temperature applications

Teresa C. Diamantino *, Rita Gonçalves, Soraia Páscoa, Isabel N. Alves, M. João Carvalho

Laboratório Nacional de Energia e Geologia, I.P. (LNEG), Estrada do Paço do Lumiar, 22, 1649-038, Lisboa, Portugal

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A B S T R A C T

The need of a higher role of solar energy within the energy mix in the coming decades obliges the collectors to increase their performance and reliability. It is demanded that the solar absorbers, as the key component of solar thermal collectors, should be low cost with high efficiency for extended lifetimes under different kinds of environments. Commercially, there are presently two main types of solutions as selective solar absorbers coatings for low temperature applications: coatings obtained by physical vapour deposition (PVD) and by paint coatings (PC). These coatings present different physical and chemical characteristics. Therefore, it is important to know how these commercial coatings degrade over time in different environments.

Results obtained with two different PVD coatings and three PC, under different accelerated aging tests, are presented. The aging tests performed included different environmental stress corrosion conditions: temperature, humidity, chlorides, sulfur dioxide and nitrogen oxides. The chlorides and the gases SO_2 and NO_2 affect distinctly the different selective coatings.

Cyclic variation of corrosion promoting gases (sulfur dioxide and nitrogen dioxide), higher humidity, salt spraying and drying seem to be an aging test that reflects the different environments where the solar thermal collectors are exposed. In addition to the contaminants, drying/wetting cycles also play an important role in degradation mechanisms of absorber coatings. So, the international standard ISO 22975-3 needs to be revised to include cyclic conditions with these contaminants.

1. Introduction

Solar energy is the most abundant and cleanest renewable energy source. Energy from the sun can be used directly for space and water heating, industrial processes, food drying, and wastewater treatment, among other uses. When solar collectors are paired with absorption or adsorption chillers, solar energy also can be used for cooling [1]. The global solar thermal capacity of unglazed and glazed water collectors in operation grew from 62 GW thermal (GW_{th}) (89 million m^2) in 2000 to 479 GW_{th} (684 million m^2) in 2019. The corresponding annual solar thermal energy yields amounted to 51 TWh in 2000 and 389 TWh in 2019 [2].

The main R&D challenges in the development of solar thermal collectors (STC) are focused on increasing reliability and long-term performance stability. Countries with high solar resource and a significant number of coastal regions with high population density, constitute a large and prospective market and a challenge in terms of reliability and durability.

In general terms, atmospheric corrosion is reported to account for more failures in terms of cost than any other factor and is the main contributor to the overall costs of corrosion in general (3.4% of the gross national product (2013) for several countries) [3].

STC have to withstand stress conditions like high temperatures, high humidity, ultraviolet irradiance or wind and snow loads depending on the geographic position [4] and atmospheric corrosivity [5,6]. In marine environments STC must resist against atmospheres with high corrosivity mainly due to high levels of chlorides. However, in some cases these areas are associated with polluted urban or industrial areas with sulfur dioxide and/or nitrogen oxides [7,8].

For a long time, the degradation of most metals in the atmosphere was attributed to the deteriorative effect of sulfur dioxide and in special environments also to chlorides. They received thorough attention in atmospheric corrosion research and are the most extensively studied pollutants [9–11].

Sulfur dioxide from burning coal or other fossil fuels is picked up by

* Corresponding author.
E-mail addresses: teresa.diamantino@lneg.pt (T.C. Diamantino), rita.goncalves@lneg.pt (R. Gonçalves), soraia.pascoa@lneg.pt (S. Páscoa), isabel.nascimento@lneg.pt (I.N. Alves), mjoao.carvalho@lneg.pt (M.J. Carvalho).

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