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Introduction

Carbon dioxide (CO_2) is the greenhouse gas that causes significant concern all over the world. Thus, it is understandable that CO_2 utilization and capturing technologies are increasingly considered as the means to hinder climate change besides of minimising the emissions. On the other hand, the utilization of CO_2 can offer added value for the products manufactured using the way that promotes circular economy and sustainability. Hence, seizing the opportunity to utilize CO_2 in the technical processes can create novel alignments among conventionally competing environmental and economic issues. [1] In this study, we demonstrate a fast method for producing the artificial patina layer on hot dip galvanized (HDG) steel utilizing supercritical carbon dioxide ($scCO_2$) treatment. This is of great significance because the formation of patina layer (which is essential for the paint adhesion) is known to take several years in atmospheric conditions. The $scCO_2$ treatment was performed in a cylindrical reaction chamber which was heated to 50° C and pressurized to 300 bar. The duration of the treatment was 60 minutes. The treated surfaces were characterized employing SEM, FTIR and H_2O contact angle measurements. Moreover, $scCO_2$-treated surfaces were also calcined in the furnace at 300°C for 2 h to study the possibility to produce semiconducting zinc oxide (ZnO) structures using this relatively simple procedure. The characterizations of the calcined surfaces were conducted using SEM, FTIR, XRD and optical spectroscopy.

Results and Discussion

Based on the SEM results, a clear change in the surface topography between untreated and $scCO_2$-treated surfaces was detected. The $scCO_2$ treatment produced thin nanowires onto surface of the specimen. These nanowires were characterized by FTIR to consist of zinc hydroxycarbonate ($Zn_x(CO_3)_y(OH)_z$). According to H_2O contact angle measurements, the $scCO_2$ treatment significantly increased hydrophobicity of the galvanized coating which resulted in good wettability of the specimen with a nonpolar polyester-melamine primer. The characterizations of $scCO_2$-treated and calcined surfaces showed that the calcination did not change the needle-like topography of the surface but the chemistry of the surface had altered into ZnO during calcination. The optical bandgap for the prepared ZnO was determined to be 3.23 eV indicating semiconducting properties.

Conclusions

In this study, we present green and rapid method to produce artificial patina by $scCO_2$ treatment on HDG steel with an emphasis to enhance its paintability. Moreover, we show that this method (combined with calcination) can be utilized to produce semiconducting ZnO structures.

References

[1] C.R. Jones, B. Olfe-Kräutlein, H. Naims, K. Armstrong, Frontiers in Energy Research, 2017, 5, 1–13