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Releasing kinetics of dissolved copper and antifouling mechanism of cold sprayed copper composite coatings for submarine screen doors of ships

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Abstract: Copper composite coatings were prepared by cold spray technology to solve the problem of biofouling and attachment on submarine screen doors of ships where the flow of seawater was fast. Cuprous oxide powder, which was difficult to deposit, was sufficiently incorporated into the coatings by plastically deformable copper powder and filled the gaps between copper particles and reduced the porosity of the coatings. During spraying, micro-hammering effect of copper particles enhanced the strength and hardness of the coatings. The release of effective antifouling components was achieved by electrochemical dissolution processes, which contained four sub-processes and could be described by kinetic equations $i = i_L[1 - exp(-F\Delta E/2RT)]$ and $i_L = FD_{CuCl_2^-}k_4[Cl^-]/(D_{CuCl_2^-} + k_{-4}\sigma)$. In the view of microcosmic point, cuprous oxide and surrounding copper played the role of cathode and anode separately, and constituted corrosion microcells which accelerated the local electrochemical dissolution of anodic copper. When cuprous oxide was dissolved, the anode and cathode interchanged, and this exchange continued to promote the electrochemical dissolution of copper within the micropores formed at the position of original cuprous oxide. The antifouling ability of the coatings was obtained by forming water film on its surface, and the water film was rich in dissolved copper elements. The concentration of dissolved copper was controlled by the electrochemical dissolution of the coatings. This mechanism was suitable for most copper-based anti-fouling materials.

Keywords: Cold spray, Antifouling mechanism, Copper, Kinetics

1. Introduction

The inhibition and control of biofouling in marine environment were the matter of great concern to shipbuilders, marine engineers and biologists. Biofouling of valve and seawater system of ships would cause reduced flow rate, or even blockage, and then safety problems [1-3]. In particular, seawater flowed fast at the inlet and outlet of submarine screen doors, so conventional organic anticorrosion and antifouling coatings were peeled off easily. We developed cold spray copper composite coatings. The coatings were great in density, hardness and attachment to substrates [4], and possessed the ability of