

Study on the anticorrosion and antibacterial properties of carboxylated nitrile butadiene rubber based composite coating

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Abstract: **【Objective】** With the rapid development of industries such as transportation, construction, and marine, the unique corrosive environment urgently demands a functional anticorrosive coating that possesses comprehensive antimicrobial and anticorrosion properties. In this study, a unique rubber-based bifunctional composite coating with anticorrosive and antibacterial characteristics is designed to suit a wide variety of production and living environments. **【Method】** The present study used a one-pot strategy to fabricate a high-performance nanocomposite coating consisting of carboxylated nitrile butadiene rubber/cellulose nanofiber/zinc oxide (XNBR/CNF-ZnO) that forms a crosslinking network by establishing hydrogen bond interactions with XNBR, thereby promoting good interfacial compatibility between the nanofillers and the XNBR matrix. The solvent resistance, antibacterial activity, and metal anticorrosion properties of XNBR/CNF-ZnO coating were studied. The mechanism of interaction between the matrix and the nanofillers, as well as the corresponding performance enhancement mechanism, were further elucidated. **【Result】** 1) It is observed by differential scanning calorimetry that the glass transition temperature (T_g) of the samples increases from $-17.1\text{ }^{\circ}\text{C}$ (XNBR/CNF-ZnO₀) to $-13.9\text{ }^{\circ}\text{C}$ (XNBR/CNF-ZnO_{0.15}), respectively, because of the addition of CNF-ZnO nanofillers. The increase in the T_g of the composite indicates a reduction in the mobility of molecular chains, which can be ascribed to the formation of a crosslinked network within the composite. 2) The gear oil absorption rates of the XNBR/CNF-ZnO₀ and XNBR/CNF-ZnO_{0.07} samples are 9.0% and 6.0%, respectively. The absorption rates of toluene in the samples fell from 208.7% to 143.4% after 188 h of impregnation. The composite sample exhibits a relatively low water absorption rate (acidic and alkaline solutions). The above results show that the expansion of rubber chains in a solvent is effectively managed by the establishment of a frame-like network structure of XNBR and CNF-ZnO. 3) The oxygen permeability coefficient of the composite coating is reduced by the addition of CNF-ZnO nanofillers ($5.80 \times 10^{-11}\text{ cm}^3\cdot\text{cm}/(\text{cm}^2\cdot\text{s}\cdot\text{Pa})$). This can be attributed to the introduction of nanofillers, which serve to compensate for the inherent defects of the coating, improve the densification of the coating, and enhance the resistance to oxygen permeability by constructing a crosslinking barrier. 4) The XNBR/CNF-ZnO_{0.05} and XNBR/CNF-ZnO_{0.07} coatings maintain their integrity with a grade of 5B in the scribe test, suggesting that the coating exhibits remarkable adhesion. 5) The pure XNBR/CNF-ZnO₀ sample does not exhibit an inhibition zone, indicating that it has little antibacterial action against *S. aureus*. The diameter of the inhibition zone of the composite coating significantly increases as the CNF-ZnO concentration increases, and all of them are significantly greater than those of the blank experimental group. 6) Electrochemical impedance spectroscopy measurements assess the effectiveness of the coatings in preventing corrosion while immersed in a corrosive environment. The modulus at the lowest frequency ($|Z|_{0.01\text{ Hz}}$) is used to assess the anticorrosion performance of coatings. The $|Z|_{0.01\text{ Hz}}$ value of bare carbon steel gradually decreased to $595\text{ }\Omega\text{ cm}^2$ after 60 hours of immersion because carbon steel can be rapidly corroded by the diffusion of the aggressive solution. The initial $|Z|_{0.01\text{ Hz}}$ value for the XNBR/CNF-ZnO₀ sample is $2.7 \times 10^7\text{ }\Omega\text{ cm}^2$ and declines slightly to $1.7 \times 10^6\text{ }\Omega\text{ cm}^2$ after 132 hours of soaking. These findings indicate that the corrosive medium has caused the corrosion channels to open, which may reach the coating/steel interface and react with the substrate. The XNBR/CNF-ZnO_{0.07} sample has a $|Z|_{0.01\text{ Hz}}$ value of $1.8 \times 10^9\text{ }\Omega\text{ cm}^2$ in the first hour of immersion, which is two orders of magnitude greater than that of the XNBR/CNF-ZnO₀ sample. The $|Z|_{0.01\text{ Hz}}$ values of the XNBR/CNF-ZnO_{0.07} sample are slightly declining after 132 hours of immersion. The XRD test reveals

that the XNBR/CNF-ZnO₀ coated carbon steel exhibits a new diffraction peak at about 16.8°, which is attributed to FeOOH when compared to bare carbon steel. The spectrum of XNBR/CNF-ZnO_{0.07} coated carbon steel does not exhibit any additional peaks. The above results show that the XNBR/CNF-ZnO_{0.07} sample has better metal anticorrosion properties. **【Conclusion】** The CNF-ZnO nanofillers establish hydrogen-bonding interactions with the XNBR, thereby significantly enhancing the crosslinking density of the XNBR/CNF-ZnO composites and achieving favorable interfacial compatibility with the XNBR matrix. Based on these findings, the mechanism underlying the crosslinking interaction between the matrix and fillers is elucidated, as well as its corresponding mechanism for enhancing performance. The XNBR/CNF-ZnO composites exhibit significant enhancements in solvent resistance, antimicrobial properties, and metal anticorrosion properties compared to the pure XNBR samples. This study introduces an innovative approach for the intelligent application of CNF-ZnO nanomaterials and XNBR, providing a new method for functional anti-corrosion coatings with antibacterial and anti-corrosion properties.