

P110SS 在海底超高温超临界 CO₂ 中的腐蚀规律研究

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摘要: 随着海上油气勘探开发逐渐向深层发展, 油井管服役环境日趋严峻, 材料在超高温高压环境下面临严重的腐蚀失效风险。目的: 为明晰在过饱和超临界 CO₂ 下低合金钢油井管的腐蚀行为和规律, 以 P110SS 为研究对象, 通过静态腐蚀失重实验, 分析了宽域温度(40℃~250℃)和超高压(4MPa~70MPa)对超临界状态下材料腐蚀速率规律的影响。利用 SEM、EDS 等分析方法, 对腐蚀产物的形态及成分等特征进行表征。结果: P110SS 在模拟海洋工况 10MPa CO₂ 分压下, 在 80℃下腐蚀速率最高, 为 2.43mm/a, 随温度升高腐蚀速率不断降低, 250℃下腐蚀速率为 0.17mm/a。在压力低于 7.35 MPa 时, 随压力增加腐蚀速率呈线性增加。当 CO₂ 脱离密相态, 压力对腐蚀速率的影响不再显著。结论: 无论 CO₂ 处于密相态或超临界态, 温度对 P110SS 的腐蚀速率影响规律均呈现先升高后降低的趋势, 腐蚀模式未发生改变。腐蚀速率在 80℃时最高, 随温度升高逐渐降低, 180℃以上基本保持平稳, 腐蚀速率受腐蚀产物的致密度控制。随 CO₂ 压力增加, 腐蚀速率逐渐升高, P110SS 腐蚀速率对处于密相态下的 CO₂ 压力更为敏感, 变化趋势与 CO₂ 在水中的溶解度有关。本研究为理解材料在超临界 CO₂ 状态下的腐蚀行为和机理提供了有益补充。

关键词: 超高温; 超临界 CO₂; 低合金钢; 腐蚀试验

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Lignin self-healing coatings based on thermo-reversible Diels-Alder reaction for anticorrosion applications

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Abstract As is widely recognized, metal corrosion presents a significant challenge worldwide, causing extensive economic loss. Coating is widely utilized as an effective and direct approach for metal corrosion prevention, with organic and polymer coatings being the most commonly applied strategy. The traditional synthesis method for organic polymer coatings is complex, and the raw materials primarily originate from petroleum-based sources, aggravating the energy crisis. Furthermore, these raw materials contain volatile organic compounds (VOCs), posing a hazard to human health. Additionally, once the coating experiences external forces, microcracks can emerge, thereby leading to a loss of its protective ability. Hence, in line with the strategic objectives of promoting environmental friendliness and sustainable development, bio-based materials like lignin have gradually replaced petroleum-based materials as a frontier in polymer science research. In this regard, researchers are focusing on combining bio-based materials with self-healing technology for metal corrosion prevention. In the current research, we explored the fabrication of thermo-reversible polymer networks made of bio-based materials to address the growing need for greener and more sustainable polymer coating. Herein, we developed thermally self-healing lignin-based coatings with strong anticorrosion performances through Diels-Alder crosslinking strategy. Accordingly, organosolv lignin was first functionalized by furan moieties and then used for thermally crosslinking by 4, 4'-bismaleimidodiphenylmethane (BMI) after spin casting on the surface of steel sheets. Under the optimum conditions, the obtained coating could generate smooth and defect

free layers. A thin layer (18 μm) of this coating could increase the E_{corr} from -481 mV (for bare steel) to $+142$ mV and reduced the corrosion rate (CR) over 3300 times. Importantly, the thermo-reversibility of the network endows excellent self-healing ability to the coating. Indeed, lignin self-healing coatings based on thermo-reversible Diels-Alder reaction provides a creative strategy for bio-based materials applied in anticorrosion applications with high-performance.

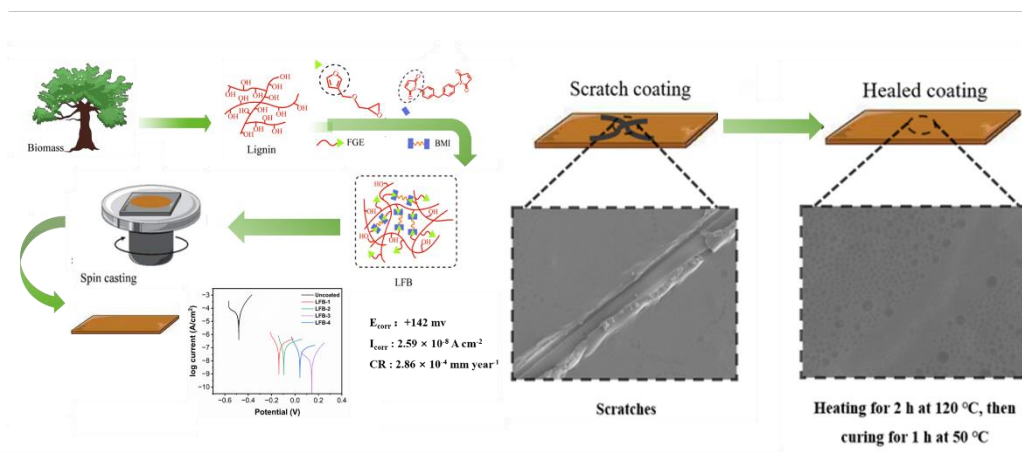


Fig. 1 Schematic method for functionalization of lignin with furan groups and then fabrication of lignin-based self-healing coatings through Diels-Alder cross-linking reaction.

Keywords: Lignin; Corrosion; Diels-Alder; Self-healing