Electroless Ni-P-ZrC nanocomposite coatings for corrosion protection of steel in the oil and gas industry

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Research problem

Meanwhile, Corrosion is one of the great challenging problems facing the industry in two main aspects; economic and environmental aspects. Most industrial plants must consider the life span of their equipment and apply frequent maintenance to corroded and old parts, otherwise, it will be subjected to a huge economic problem Several reports have shown that many oil companies had damaged pipelines due to corrosion, and that oil leakages created environmental pollution and ecological loss

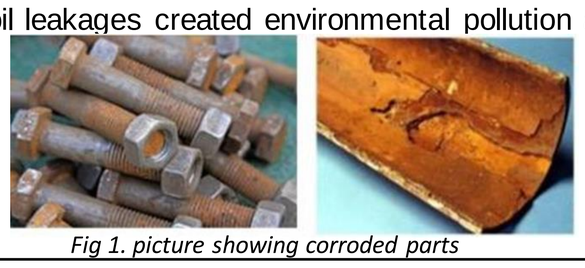


Fig 1. picture showing corroded parts

Research Questions

What is the most efficient way to fabricate a coat that can have both anticorrosive behavior and high toughness and hardness properties?

What is the effect of ZrC on the mechanical and corrosion properties?

What are the best measures to evaluate the effect of ZrC Nanoparticles as reinforcement to enhance the properties Ni –P matrix?

Research Hypothesis

This research is to assess that if a novel ceramic Nano reinforcement material (Zirconium carbide) is embedded to the Ni-P matrix in a tailored chemical bath using electro less deposition technique, then a nanocomposite coat will be formed with enhanced mechanical properties and higher corrosion resistance

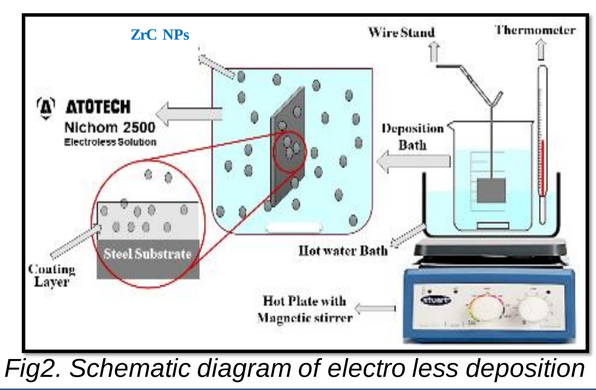


Fig2. Schematic diagram of electro less deposition

Materials and equipment

Materials: Steel substrate- Nickel phosphorous solution- Zirconium carbide nanoparticles

Equipment:

Preparation equipment	Testing equipment
Polisher/grinder Ultrasonicator	**Structural characterization**: SEM(scanning electron microscope)– AFM(Atomic force microscope) XRD(X-ray diffraction)
Hot plate and magnetic stirrer Digital balance – PH meter	**Mechanical characterization:** Vickers hardness tester
	Corrosion testing: Gamry device

Experimental Steps

The procedure involves four main steps:

1. **Pre treatment**
2. **Electro less deposition**
3. **Post treatment**
4. **testing**

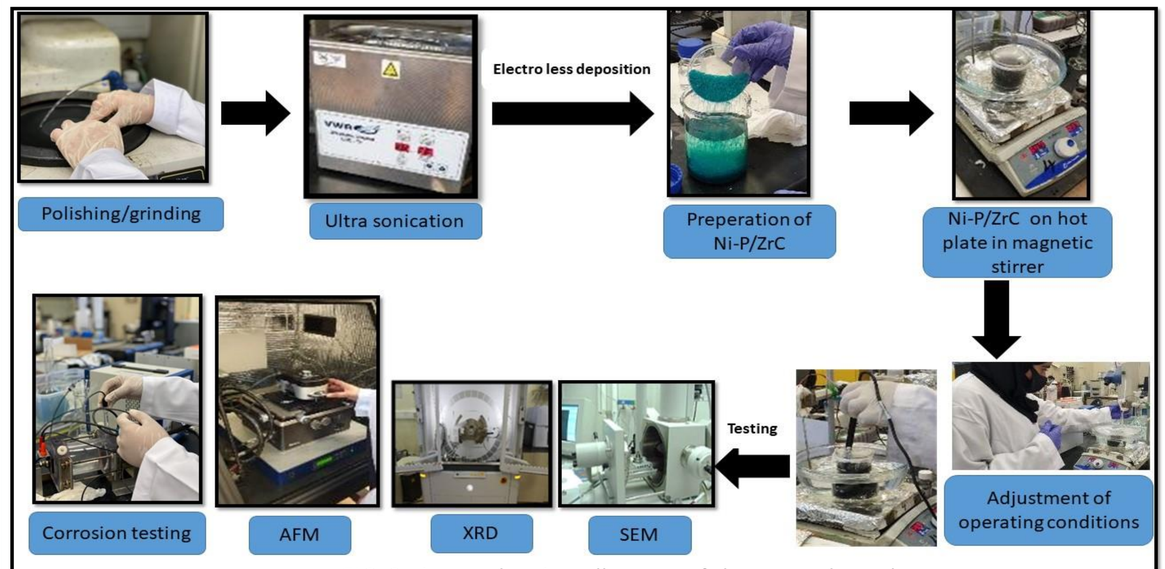


FIG. 3:picture showing all stages of the research work

Results and data analysis

SEM results:

Ni-P (a & c), and Ni-P-ZrC nanocomposite coatings

(b, d) shows that the incorporation of the ZrC to Ni –P showed more nodules and confirms effective incorporation of the ZrC.

Elemental mapping: Zr, C, P and Ni confirm the incorporatio matrix.

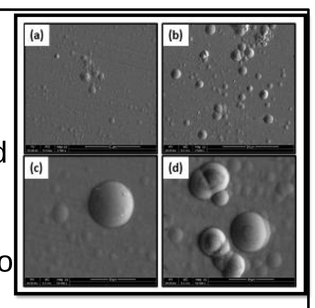


Fig 4 :SEM results

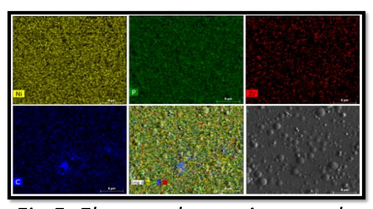


Fig 5: Elemental mapping results

XRD:

broad peak of nickel has sharpened in Ni-P-ZrC nanocomposite coatings due to p ZrC Nanoparticles

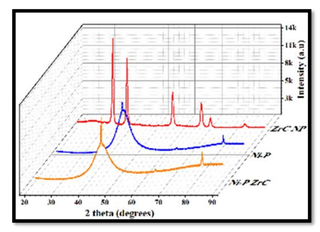


Fig 6: XRD results

AFM:

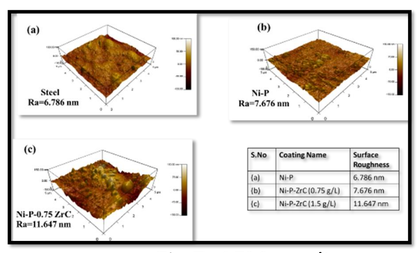


Fig 7: AFM results

_Surface roughness(Ra) increases from steel substrate to Ni-P to Ni-P/ZrC

Micro hardness test:

The hardness is enhanced after the incorporation of ZrC

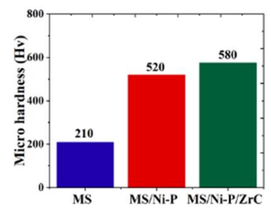
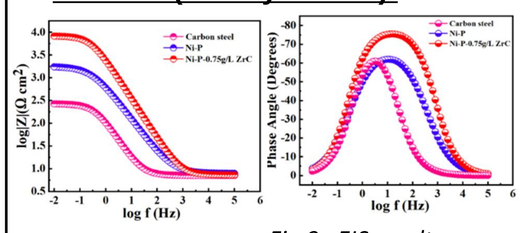


Fig 8: Microhardness results

EIS test (Gamry device):



Ni-P/ZrC coatings are more corrosion Ni-P than the Ni-P coatings which is more resistant than the steel substrate

Fig 9 : EIS results

Conclusion and Recommendations

Ni-P/ZrC nanoparticles coatings were successfully deposited on the steel substrate by electroless deposition technique. The SEM, XRD and AFM analysis confirmed the incorporation of the ZrC nanoparticles in the Ni-P matrix. Ni-P/ZrC nanocomposite coating prepared by electro less deposition showed high mechanical characteristics by micro hardnesss test and improved anticorrosion characteristics from EIS test, thus suggesting them as a powerful coating material.

future researches for the development of new materials of higher performance and more environmentally friendly is highly recommended.
Also it is recommended to try these coats in different applications

References

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