The Use of Starch Silver Nanoparticles (AgNPs) for the Inhibition of Mild Steel Using Weight Loss Technique.

BY

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INTRODUCTION

- **The field of nanotechnology is one of the most active areas of research in material science. Nanotechnology has achieved status as one of the critical research endeavours in the 21st century as scientist harness the unique properties of atomic and molecular assemblage built at the nanometer-scale (Joerger, 2000).**
- **Nanotechnology is the manipulation of matter on an atomic, molecular and super molecular scale (Drexler & Eric, 1986). Generally, nanotechnology works with materials, device and other structures with at least one dimension size from 1-100 nanometers.**

INTRO CONTD.

- **Nanotechnology may be able to create many new materials and devices with a vast range of application, such as in medicine, electronics, biomaterials and energy production. (Buzea, et al., 2007).**
- **Nanoparticles involve the combination of constituent elements into a single or unified entity. Like in the case of silver nanoparticles (nanoparticles of silver between 1 nm and 100 nm in size) in which some are composed of a large percentage of silver oxide due to large ratio of surface-to-bulk silver atoms.**

INTRO CONTD.

- **Silver nanoparticles have unique optical, electrical, and thermal properties and are being incorporated into products that range from photovoltaics to biological and chemical sensors. Examples include conductive inks, pastes and fillers which utilize silver nanoparticles for their high electrical conductivity, stability, and low sintering temperatures.**
- **An increasingly common application is the use of silver nanoparticles for antimicrobial coatings, and many textiles, keyboards, wound dressings, and biomedical devices now contain silver nanoparticles that continuously release a low level of silver ions to provide protection against bacteria (Steven, 2016).**

INTRO CONTD

- **The use of corrosion inhibitors is one of the most practical methods for the protection of metals against corrosion, especially in acid media. The corrosion inhibitors are generally used to protect metals against the attack of the acid solutions. (Popova *et al*., 2003; Ali *et al*., 2003)**
- **Natural inhibitors substances are more attractive than synthesized organic inhibitors because they are environmental friendly, nontoxic, cheap and readily available source of materials. In a "green" synthetic strategy, it is important to use nontoxic chemicals, environmentally benign solvents, and renewable materials. (Ali *et al*., 2003).**
- **Mild steel is popular in the construction of different structures like pipelines, thermal chemical reactor and cooling system, since it is excellent in performance, highly recyclable, (Lucas *et al*., 2016).**

MATERIALS AND METHOD

- **Reagents**
- **Silver Nitrate ($AgNO_3$), Hydrochloric Acid (HCl), Ethanol, Acetone, Starch, Deionized water**
- **Sample Collection**
- **$AgNO_3$, HCl and acetone of analytical grade were purchased from Sigma Aldrich. Pure starch was obtained from Chemistry Department, Ahmadu Bello University, Zaria. The sheet of mild steel was obtained from Engineering Department, Ahmadu Bello University, Zaria.**

MATERIALS AND METHOD CONTD.

Preparation of the Mild Steel

- **The sheet of mild steel obtained were mechanically press-cut into coupons of length and diameter 49 mm and 10 mm respectively and thoroughly polished so as to obtain a shinny surface then degreased with ethanol and dried with acetone. (ASTM G1-90, 1999).**
- **The coupons with purity 99.25% Fe, had the chemical composition 0.64% Mn, 0.12% C and 0.10% Si (using Thermo Scientific Niton XL2 XRF Analyzer) were used for corrosion inhibition studies. All prepared steel sample were preserved in a desiccator to avoid moisture (Mobin, 2011).**
- **Reagent Preparation**
- **The aqueous solution of 0.5 M HCl with a percentage purity of 36% and a specific gravity of 1.18 was prepared in 250 cm^3 volumetric flask using deionized water.**
- **Similarly, an aqueous solution of 0.1 M $AgNO_3$ i.e molar mass of 170 $gmol^{-1}$ was prepared using deionized water in a 200 cm^3 volumetric flask (Obot *et al*., 2013).**

MATERIALS AND METHOD CONTD.

Preparation of Starch

- **Test for Starch Solubility: The solubility of the starch in water was determined by adding 2.5 cm^3 of water into a 5 cm^3 test tube. To the water, gradually add your starch in portions starting from 100 mg. the addition is done till the point when the solution becomes saturated. The total amount of starch added in g/L is the solubility of the starch 100g/L (30^oC).**
- **Test for Bulk Density: The bulk density in kg/cm^3 which is the weight per unit volume of the starch was ascertained by taking the weight of the starch and dividing it by the volume i.e d = m/v. (300 $kgcm^{-3}$)**
- **Test for pH: The use of pH meter which was used to probe the hydrogen ion activity of the starch was preceded by a litmus test using a litmus paper to ascertain if the starch was basic or acidic. The no colour change in the litmus paper indicates neutrality. 7.5 (20 g/L H_2O, 27^o C) (Kalra *et al.,* 1995).**

MATERIALS AND METHOD CONTD.

- **Synthesis of Silver Nanoparticles (AgNP)**
- **The prepared 0.1 M aqueous solution of $AgNO_3$ was used for the synthesis of silver nanoparticles.**
- **5 cm^3 of starch was added to 95 cm^3 of 0.1 M aqueous solution of $AgNO_3$ in 250 cm^3 Erlenmeyer flask, was mixed thoroughly by manual shaking and exposed to sunlight for reduction into Ag^+ ions for 15 minutes. The colour change (reddish brown) signaled the formation of the composite. (Obot *et. al.,* 2013)**

MATERIALS AND METHOD CONTD.

Weight Loss Measurement

- **The weight loss experiment was performed for duration of 8 hrs (following ASTM designation G1–90 standard).**
- **The cleaned mild steel coupons were suspended in 200 cm^3 beakers containing 150 cm^3 of test solutions maintained at 30, 40, 50, 60 and 70^oC in a thermostated bath with the aid of hooks.**
- **The concentration of inhibitor (starch) in HCl was kept at 50 mg/L. The weight loss taken was the difference between the weight at a given time and the original weight of the coupons.**
- **The measurements will be carried out for the uninhibited solution (blank) and solutions containing starch silver nanoparticles (Mobin, 2011).**

MATERIALS AND METHOD CONTD.

- **The corrosion rates were determined using the equation:**

$$\text{Corrosion rate (mpy)} = \frac{534W}{pAt} \qquad (1)$$

- **Where: W is weight loss in mg; p is the density of specimen in gcm^{-3}; A is the area of specimen in sq. inch and t is exposure time in hours.**

- **The %IE of starch silver nanoparticle was evaluated using the following equation:**

$$\%IE = \frac{(CRo - CRi)}{CRo} \times 100 \qquad (2)$$

- **Where: CR_o is the corrosion rate of mild steel in absence of inhibitor and CRi is corrosion rate of mild steel in presence of inhibitor (James *et. al.,* 2007)**

RESULUT AND DISCUSSION

- **From the calculated values in the table, it can be seen that the corrosion rate decreases in addition of inhibitor (AgNPs) in contrast to that of the blank solution.**

Temperature (°C)	C.R (mpy) in acid (blank) After 8 hours	C.R (mpy) in inhibitor After 8 hours	% Efficiency (%IE)
30	0.322	0.022	93.168
40	1.505	0.147	90.210
50	3.580	0.394	88.994
60	4.296	0.644	85.009
70	4.580	0.788	82.806

Table 1: Calculated values for corrosion rate (in blank and inhibitor) and inhibition efficiency

RESULUT AND DISCUSSION CONTD.

The plot of %IE against temperature further reveals that at higher temperature, the inhibition efficiency is reduced showing a maximum efficiency of 93.168% at 30^{o}C. A decrease in %IE with increasing temperature suggests possible desorption of some of the adsorbed starch molecules from the metal surface at higher temperatures.

RESULUT AND DISCUSSION CONTD.

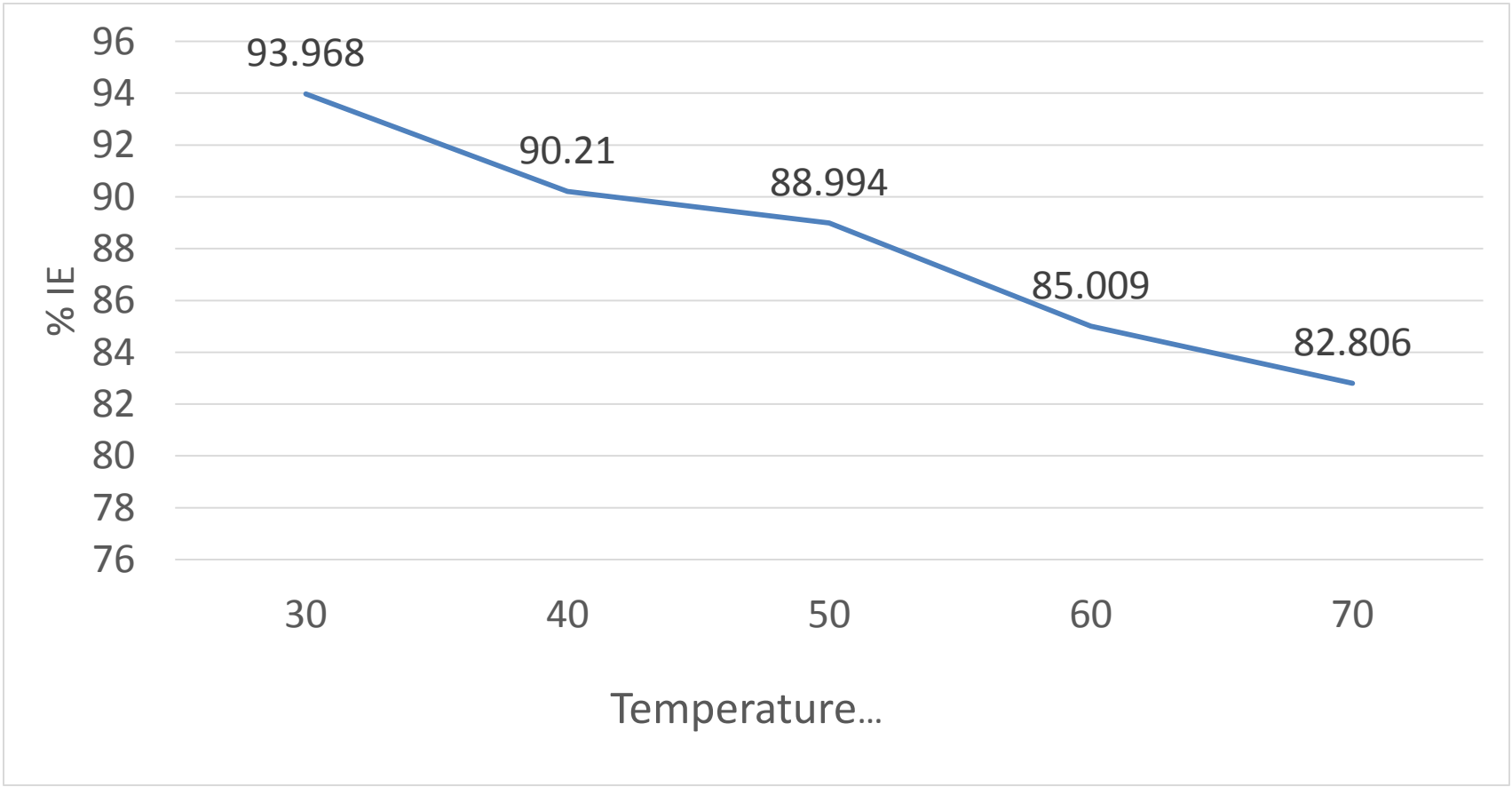

Figure 1: Plot of inhibition efficiency (% IE) against temperature on mild steel surface in 0.5 M concentrated HCl

CONCLUSION

- **This study shows that starch AgNPs acts as a good capping agent and inhibitor of mild steel in acidic medium.**
- **The results do support the claim; Starch AgNPs is a good inhibitor for the corrosion of mild steel.**
- **The data derived from the weight loss measurement suggests that it is an adsortion inhibitor.**
- **It was also seen that the binding interactions between starch and AgNPs are weak and as such dissociates at higher temperature, allowing the separation of the synthesized particles.**

Thank you for listening.

Questions…