INHIBITIVE BEHAVIOUR OF TOBACCO EXTRACT ON CORROSION OF MILD STEEL IN ACIDIC AND SALTY MEDIA

By

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ABSTRACT

Corrosion behaviour of mild steel in 0.1M/HCl, 0.1M/H_2SO_4 and 3.5% NaCl solution free from and containing varying concentrations of tobacco extract was studied by the fundamental weight loss measurement. The electric top loading balance was used to take the weight of mild steel sample at 24hours interval progressively for 168hours at room temperature and in stagnant condition. Results obtained indicates that the Tobacco extract at maximum concentration (50%) reduced the rate of corrosion of mild steel in 0.1M/HCl and 0.1M/H_2SO_4 while the inhibitor concentration of 35% average gave complete protection against corrosion of mild steel in 3.5%Nacl. It is concluded that tobacco extract in the range 20%-50% is capable of reducing/or eliminating corrosion of mild steel in acidic and salty environments.

Keywords: ***Inhibitive effect, corrosion behaviour, Tobacco extract, mild steel, inhibitor concentration.***

1.0 INTRODUCTION

Corrosion occurs in different forms in metallic structure such as in the construction industries, industrial process equipment and allied industries [1].

Mild steel which accounts for a great deal of metallic material in these industries is susceptible to various forms of corrosion such as pitting corrosion, uniform corrosion, intergranular corrosion, stress corrosion cracking and fatigue corrosion[2].

Corrosion in "local" perspective represents a loss in production time due to plant/equipment failure, resultant likely fatal accident to the person involved and manpower loss [3]. In a global perspective it represents a tremendous economic loss and much has to be done to combat it [4].

Many current corrosion control measure use coatings, conversion layers, material selection, design, cathodic protection, inhibition and

environment alterations among other control measures.

Corrosion inhibition is of great practical importance, being extensively employed in minimizing metallic wastage in engineering materials in service. The corrosion inhibition process is a surface mechanism, which involves the adsorption of organic compound on metal surface, thereby reducing the rate of corrosion [5].

The influence of synthetic organic compounds as inhibitor on corrosion of mild steel in acid media and salt solution has been severally investigated [1,4-9, 11-13]. However, studies on the use of natural products as inhibitors for mild steel in acid media and salt solution are somewhat rare. Extracts from different parts of plants consists of a mixture of various natural organic compounds [10]. The mixture of various natural organic compounds does possess are no doubts about the synergistic effect on the corrosion processes of metals [11]. It is therefore suffice to attempt to evaluate the inhibitive tendency of a certain plant extract on the corrosion of metals in some media. Thus, the inhibitive tendency of tobacco extract on the corrosion behaviour of mild steel in two acidic (HCl & H_2SO_4) and salt environment (NaCl) was investigated in this work.

It has been reported that tobacco (nicotiana rustica)[11] contains more than 2,700 different compounds with relatively large concentration of carboxylic acids, polyphenols, terpenes and amines. Many of these chemicals can be electro-chemically active and could possibly function as metal corrosion inhibitor [12-13].

This research work therefore centrally seeks to determine the potency of nicotiana rustica as a possible natural organic inhibitor in the corrosion process of mild steel in acidic and salty media. It equally evaluated the relative concentration of the inhibitor that could give measurable corrosion retardation in the different media considered.

2.0 METHODOLOGY

2.1 Test Materials Sourcing & Material Preparation

The mild steel sample used for this study was obtained and analyzed at the Grand Foundry Nigeria Limited, Ikeja, Nigeria in the form of steel rod[1]. Test specimens in the form of rod with diameter 8mm and length 20mm were machined from the parent mild steel rod. A 3mm hole was drilled on one end of the specimen for suspension in the corrodant and inhibitor mix. The samples surfaces were ground with different grades of emery paper to 120 grit finish, degreased by washing in acetone, dried and weighed on an electric top loading balance. The test specimens were subsequently placed in a desiccator to prevent atmospheric corrosion before experimentation. The composition of the mild steel specimen was determined through atomic

absorption. The mild steel specimen composition spectroscopy is given in Table 1:

2.1.2 Corrodant and Inhibitor Preparation

The corrosion media were prepared by mixing distilled water and concentrated acid solutions and sodium chloride in the correct proportions to produce 0.1M HCl, 0.1M H_2SO_4 and 3.5% NaCl solution respectively.

Fresh tobacco leaves obtained from the bush were allowed to dry naturally in the sun. The dried leaves were crushed, stewed with water and soaked in the water for 24 hours. The residue was filtered and the filtrate evaporated leaving behind a brown powder.

The reagents for the corrosion media were commercially produced.

2.1.3 Apparatus Set Up

The apparatus used for the experiment was set up as indicated in Figure 1. The container were washed with detergent, rinsed in distilled water and dried in a warm oven. Inhibitor solutions of known concentrations with corrodants were introduced together into the containers and specimen suspended in such a way that they were completely immersed in the solution.

2.2 Experimental Method

The specimen was subjected to atomic spectroscopy to determine the elemental constitution of the mild steel sample. The result of the spark test is given in Table1.

The total geometric surface area of the specimens exposed was 6.033cm^2 and the average weight of the samples before suspension was 8.50gm. The samples were suspended through the holes drilled in one of its ends. Three 250ml plastic containers which separately contained 100ml of 0.1M HCl, 0.1M H_2So_4 and 3.3% NaCl were maintained at room temperature and in stagnant position. This represents the uninhibited experiment as well as the control experiment.

Previously weighed mild steel specimens were each suspended in each plastic container containing the uninhibited solutions. The specimens of the control experiment were retrieved from their corrodant at 24 hours interval progressively for 168 hours (7days). They were rinsed in distilled water and properly cleaned in acetone to remove any corrosion product on their surface. The samples were dried and weighed. The weight loss was calculated in gramme as the difference between the initial weight prior to suspension and the weight after removal of the corrosion products. Each reading recorded was an average of two readings recorded to the nearest 0.0001g on a digital electric top loading balance.

The experiments were repeated with the introduction of five different concentrations (10% to 50%) of the inhibitor separately in five plastic

containers containing 100ml of 0.1M HCl solution. Previously weighed specimens were then suspended in the corrodant inhibitor mix. Each sample was retrieved from the solution at 24 hours interval progressively for 168 hours (7 days). The difference in weight of the samples was taken as the weight loss. The above procedure was repeated for 0.1M H_2S0_4 solution and 3.5% NaCl solution.

The inhibition efficiency at each concentration of inhibitor used was calculated using the equation proposed by Larabi and Harek [7].

$$\text{Inhibition efficiency } \int_I = 100 \times \frac{(Cr_u - Cr_i)}{Cr_u} \quad (1)$$

Where $\int_I$ = Inhibition efficiency

Cr_u = corrosion rate of uninhibited samples

Cr_i = corrosion rate of inhibited samples

The corrosion rate was determined using the equation proposed by Larabi and Harek [7] which is essentially a condensation of the formula proposed by Fontana [14].

$$\frac{\text{Weight Loss (mg)}}{\rho \times \text{Total surface area of exposure} \times \text{Total time of exposure}} \quad (2)$$

$$\Rightarrow \text{Corrosion Rate } (C_i) = \frac{WL}{X_A t}$$

Where WL = Weight loss in mg

ρ = Density of material g/cm^3

X_A = Total Surface Area of Exposure (cm^2)

t = Total Time of Exposure (hr)

4.0 Discussion of Result

The result of the spark test given in Table 1 revealed that the mild steel sample is 0.2C hypo-eutectoid plain carbon steel with traces of other elements residued from metal extraction process. Their levels are insignificant to influence any change in the chemistry of the mild steel in the various corrosion media.

Figure 2 shows the weight loss versus exposure time for mild steel suspended in 0.1M H_2SO_4 free from and containing varying concentrations of tobacco extract. It could be observed from the figure that all the samples showed significant weight loss irrespective of whether they were inhibited or not. This supports the findings of Fadayomi [13] that corrosion inhibitors may not totally stop corrosion but increase the time for the onset of corrosion and reduce its eventual rate. The figure also indicates that the uninhibited specimen (R_2) has the highest corrosion rate. This may be attributed to the relative concentration of the uninhibited acid solution with high volume of sulphate ions in it which is known to be an active agent of corrosion. This ion continually breaks down the protective corrosion product on the steel and expose it to further corrosion hence the higher weight loss of the uninhibited test sample through out the exposure period [2]. The Figure also showed that the more the concentration of the inhibitor in the acid solutions the lesser the rate of

corrosion which is in agreement with the submission of Evans[12] that the inhibition efficiency of organic substances are known to be related to inhibition concentration among other factors.

Figure 3 shows the plot of weight losses versus exposure time for mild steel suspended in 0.1M HCl free from and containing varying concentration of tobacco extract. Expectedly the uninhibited sample (R_1) had the highest corrosion rate while the inhibited samples had much lower corrosion rate with respect to the increase in concentration of inhibitor. Comparison of Figures 2 and 3, revealed that corrosion is more suppressed in HCl solution than H_2SO_4 solution. This may be due to the ability of the inhibitor to either slow the cathodic reaction or selectively precipitate on cathodic sites to increase the surface impedance and limit the diffusion of reducible species in HCl solution than in H_2SO_4 solution. Thus, the effects of the inhibitor irrespective of the concentration are more effective in HCl then in H_2SO_4 solution[9].

Figure 4 is a plot of weight loss versus exposure time for mild steel immersed in 3.5% Nacl medium. The uninhibited sample (Rs) shows relative high corrosion rate throughout the exposure period. The high concentration of chloride ion in this medium could have been responsible for the continuous breakdown of the otherwise protective film on the steel within the medium. The sample inhibited with 10% inhibitor concentration (S1) showed weight loss throughout the exposure time while other samples inhibited with 20% - 50% inhibitor concentration showed no weight loss throughout the exposure period, thus producing excellent inhibitive property on the steel in this medium. This may be attributed to the ability of the inhibitor at higher concentrations to cause a large anodic shift of the corrosion potential, forcing the metallic surface into passivation range[9].

The relationship between inhibition efficiency versus inhibition concentration of tobacco extract in 0.1M HCl, 0.1M H_2SO_4 and 3.5% NaCl is shown in Figure 5. The Figure confirmed that the inhibition efficiency of the inhibitor is highest in the 3.5% Nacl solution as discussed previously. The Figure equally showed that inhibition efficiencies in HCl and H_2SO_4 solution are dependent on the inhibition concentration and that the maximum attainable efficiency in 0.1M HCl and 0.1M H_2SO_4 is in the range 50-60% at inhibitor concentration of 50% tobacco extract *(nicotiana rustica)*.

5.0 CONCLUSION

The present study has established that tobacco extract (nicotiana rustica) does not completely stop corrosion of mild steel in acidic media but at high concentrations, the inhibitive strength becomes significant. However, it effect is greatly noticed in the 3.5% NaCl solution.

It is concluded that an average inhibitor concentration of 35% tobacco extract can give complete protection against. Corrosion of mild steel in 3.5% NaCl solution. The work revealed that the inhibition efficiency of tobacco extract on corrosion of mild steel is in the order 3.5% NaCl > 0.1M H_2SO_4 > 0.1 M HCl.

6.0 ACKNOWLEDGEMENT

The authors acknowledge the assistance of the Management of Grand Foundry Nigeria Limited, Ikeja, Lagos, Nigeria for providing the mild steel used for this study. The assistance offered by staff of the Science Laboratory Technology Department, Federal Polytechnic, Ado-Ekiti, Nigeria is equally acknowledged.

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Table 1: Elemental Constitution of Mild Steel Sample (AAS)

Element	C	Si	Mn	Cr	Ni	P	S	*Fe*
%	0.2	0.28	0.60	0.10	0.12	0.004	0.004	98.6

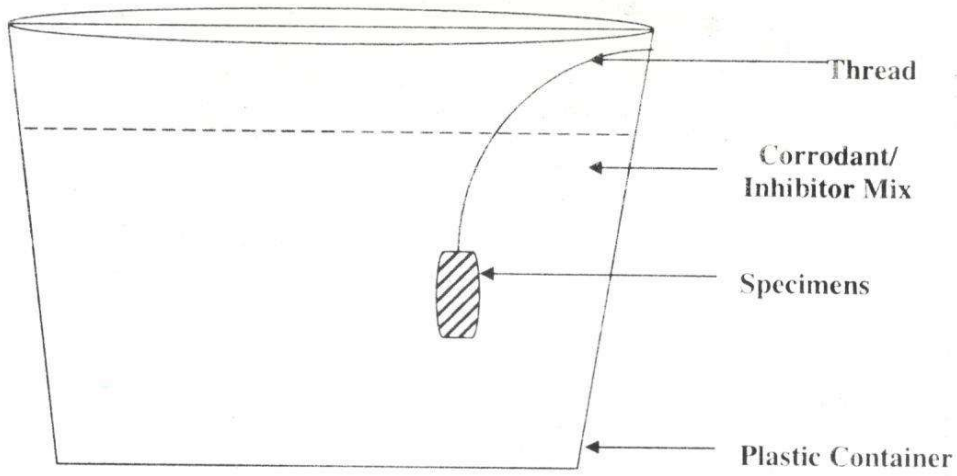

Fig. 1: Experimental Set-up

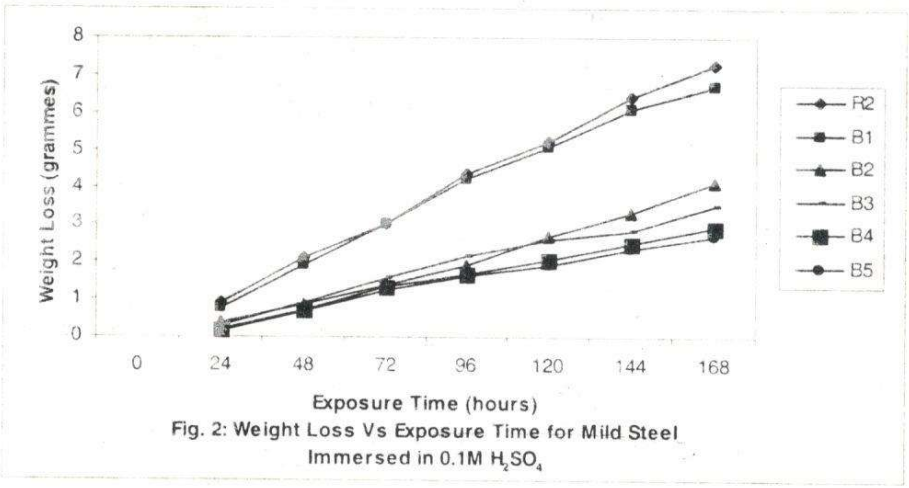

Fig. 2: Weight Loss Vs Exposure Time for Mild Steel Immersed in 0.1M H_2SO_4

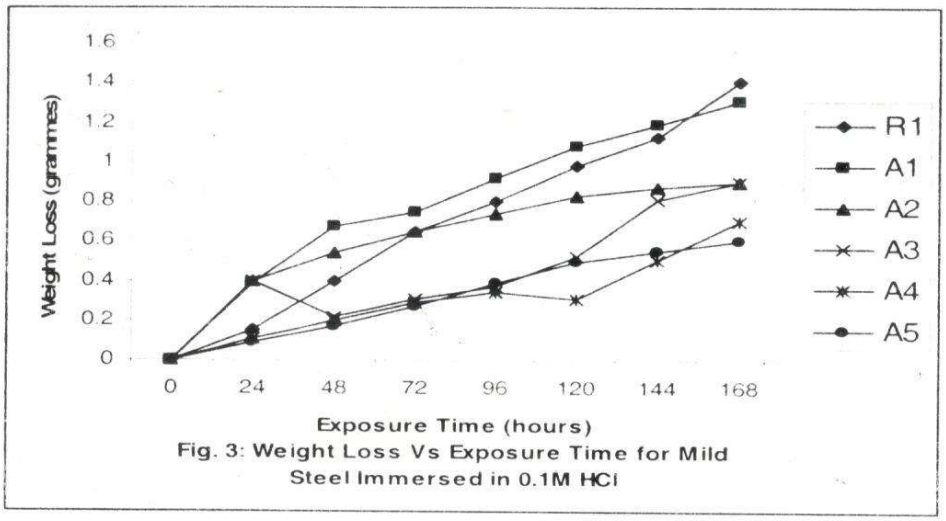

Fig. 3: Weight Loss Vs Exposure Time for Mild Steel Immersed in 0.1M HCl

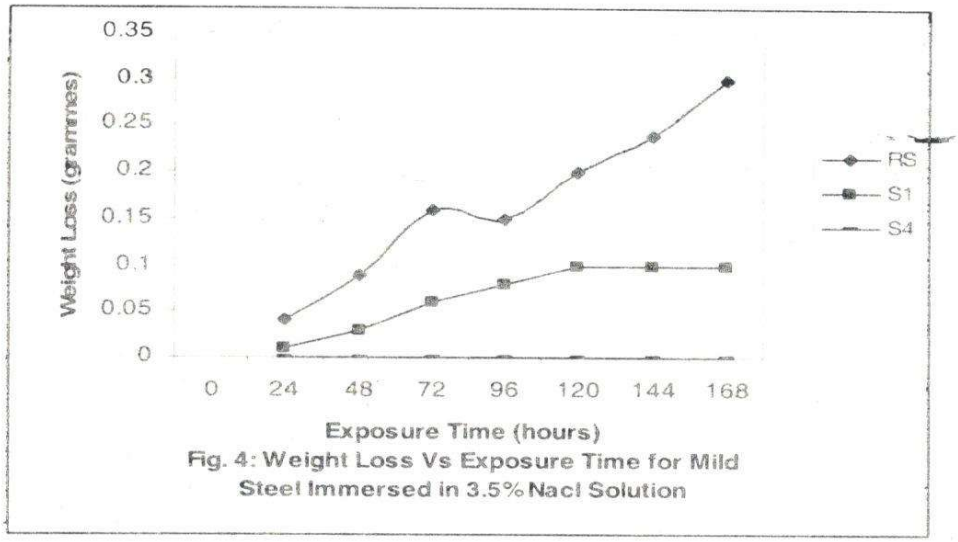

Fig. 4: Weight Loss Vs Exposure Time for Mild Steel Immersed in 3.5% Nacl Solution

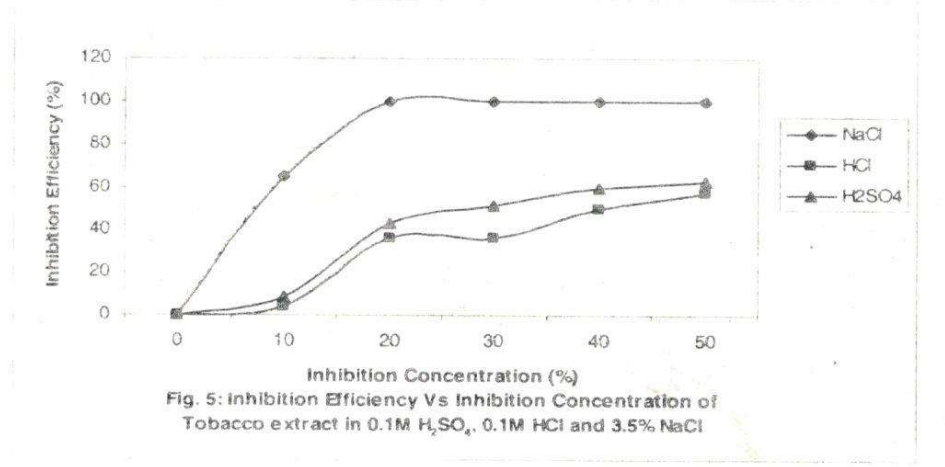

Fig. 5: Inhibition Efficiency Vs Inhibition Concentration of Tobacco extract in 0.1M H_2SO_4, 0.1M HCl and 3.5% NaCl

APPENDIX I

SAMPLES IN HCL SOLUTION

R_1 Sample in 0.1MHcl Uninhibited

A_1 Sample in 0.1MHcl containing 10% inhibitor concentration

A_2 Sample 0.1MHcl containing 20% inhibitor concentration

A_3 Sample 0.1MHcl containing 30% inhibitor concentration

A_4 Sample in 0.1MHcl containing 40% inhibitor concentration

A_5 Sample in 0.1MHcl containing 50% inhibitor concentration

SAMPLES IN H_2SO_4 SOLUTION

R_2 Sample in 0.1MH_2SO_4 Uninhibited

B_1 Sample in 0.1MH_2SO_4 containing 10% inhibitor concentration

B_2 Sample in 0.1MH_2SO_4 containing 20% inhibitor concentration

B_3 Sample in 0.1MH_2SO_4 containing 30% inhibitor concentration

B_4 Sample in 0.1MH_2SO_4 containing 40% inhibitor concentration

B_5 Sample in 0.1MH_2SO_4 containing 50% inhibitor concentration

SAMPLES IN SALT SOLUTION

R_s Sample suspended in 3.5% Nacl Uninhibited

S_1 Sample immersed in 3.5% Nacl containing 10% inhibitor concentration

S_2 Sample in 3.5% Nacl containing 20% inhibitor concentration

S_3 Sample in 3.5% Nacl containing 30% inhibitor concentration

S_4 Sample in 3.5% Nacl containing 40% inhibitor concentration

S_5 Sample in 3.5% Nacl containing 50% inhibitor concentration

APPENDIX II

RESULTS

Table 2: Weight Loss of Mild Steel in 0.1M H_2S0_4

Samples	R_2			B_1			B_2			B_3			B_4			B_5		
Time (Hrs)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	*Weight Loss (g)*
0	8.50	-	-	8.50	-	-	8.50	-	-	8.60	-	-	8.50	-	-	8.50	-	-
24		7.60	0.90		7.75	0.75		8.10	0.40		8.30	0.30		8.32	0.18		8.35	*0.15*
48		6.40	2.10		6.60	1.9		7.65	0.85		7.70	0.90		7.80	0.70		7.82	*0.68*
72		5.50	3.00		5.50	3.0		7.10	1.40		7.00	1.60		7.15	1.35		7.25	*1.25*
96		4.12	4.38		4.30	4.20		6.60	1.90		6.45	2.15		6.81	1.69		6.88	*1.62*
120		3.30	5.20		3.40	5.10		5.80	2.70		6.00	2.60		6.45	2.05		6.57	*1.94*
144		2.10	6.40		2.40	6.10		5.18	3.32		5.75	2.85		6.00	2.50		6.15	*2.33*
168		*1.20*	*7.30*		*1.80*	*6.70*		*4.40*	*4.10*		*5.10*	*3.50*		*5.60*	*2.90*		*5.80*	*2.70*

Table 3 Weight Loss of Mild Steel in 0.1M HCl

Samples	R_2			A_1			A_2			A_3			A_4			A_5		
Time (Hrs)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	*Weight Loss (g)*
0	8.40	-	-	8.50	-	-	8.40	-	-	8.50	-	-	8.50	-	-	8.60	-	-
24		8.25	0.15		8.11	0.39		8.00	0.40		8.35	0.40		8.39	0.11		8.51	*0.09*
48		8.00	0.40		7.83	0.67		7.86	0.54		8.28	0.22		8.30	0.20		8.43	*0.17*
72		7.75	0.65		7.75	0.75		7.75	0.65		8.19	0.31		8.21	0.29		8.33	*0.27*
96		7.60	0.80		7.58	0.92		7.66	0.74		8.13	0.37		8.16	0.34		8.21	*0.39*
120		7.42	0.98		7.42	1.08		7.57	0.83		7.98	0.52		8.09	0.31		8.11	*0.49*
144		7.28	1.12		7.31	1.19		7.53	0.87		7.69	0.81		8.00	0.50		8.05	*0.55*
168		*7.00*	*1.40*		*7.20*	*1.30*		*7.50*	*0.90*		*7.60*	*0.90*		*7.80*	*0.70*		*8.00*	*0.60*

Table 4: Weight Loss of Mild Steel in 3.5% Nacl

Samples	R_S			S_1			S_2			S_3			S_4			S_5		
Time (Hrs)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Initial Weight (g)	Final Weight (g)	Weight Loss (g)
0	8.60	-	-	8.50	-	-	8.40	-	-	8.50	-	-	8.40	-	-	8.40	-	-
24		8.56	0.04		8.49	0.01		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00
48		8.51	0.09		8.47	0.03		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00
72		8.48	0.48		8.44	0.06		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00
96		8.45	0.15		8.42	0.08		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00
120		8.40	0.20		8.40	0.10		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00
144		8.36	0.24		8.40	0.10		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00
168		8.30	0.30		8.40	0.10		8.40	0.00		8.50	0.00		8.40	0.00		8.40	0.00