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Corrosion studies of stainless steel and carbon steel in aqueous solutions of sodium glycinate used for CO_2 capture

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Abstract: Corrosion is a well-known and serious issue in carbon dioxide (CO_2) absorption process, which causes huge maintenance cost for restoration of corroded equipment and pipelines. Aqueous sodium glycinate (SG) is a potential solvent for CO_2 capture. Corrosion study of SG solvent is very crucial for its practical applications, as such data is very limited in an open literature. Therefore, to address this significant gap, the corrosion rates of Stainless Steel (SS-304) and Carbon Steel (CS-1018) were investigated in this study by employing weight loss method using SG solvent at three different temperatures (303.15, 313.15, and 333.15 K) and concentrations (0.10, 0.20 and 0.30 mass fraction) of industrial importance. The results revealed that SS304 showed negligible corrosion in SG solvent with marginal effect of temperature and concentration. However, significant effect of temperature and concentration was observed on corrosion rate of CS1018 in SG solvent. At highest studied temperature of 333.15 K and high concentration (0.30 mass fraction), the corrosion rate of SS304 and CS1018 in SG solvent is 3.291 mpy and 32.203 mpy respectively. Moreover, the corrosion rate of CS1018 in SG solvent was compared with methyldiethanolamine (MDEA), monoethanolamine (MEA), and diethanolamine (DEA). It was found that SG solvent showed less corrosivity than various amine solvents. The findings of this study provide the guidance for practical application for SG solvent in CO_2 capture process. Also, the data

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obtained could significantly help the design engineers to establish the appropriate operating conditions of CO_2 capture process to control the corrosion.

Keywords: corrosion behavior; metallic materials; weight loss method; amino acids; CO_2 absorption.

INTRODUCTION

Corrosion is a well-known issue in acid gas (CO_2) removal operations, which is considered as most serious problems in CO_2 absorption. The corrosion of equipment, pipelines, and other utilities in the CO_2 absorption process causes unscheduled downtime, loss of production; reduce the equipment life, and sometimes even fatal injury. The production loss for a typical plant due to the corrosion varies from 10,000 to 30,000 USD per day. Additionally, various management expenses are also incurred for the restoration of corroded system and its mitigation. Although, it is impossible virtually to eliminate the corrosion, however, it can be minimized and controlled. Chemical and design engineers always strive for the minimization of the corrosion in the CO_2 capture plants. To accomplish this, the prior knowledge of chemical solvents, and the materials of construction for CO_2 capture plant fabrication is always important, especially when the new chemical solvents are designed for CO_2 capture.[1-4] Therefore, in order to minimize and control the corrosion in CO_2 absorption plant, it is very essential to evaluate the corrosion tendency of the new solvents to be used for the absorption of CO_2. Aqueous SG solvent is promising in CO_2 absorption characteristics. Various studies on SG solvent have been carried out including physical properties and solubility of CO_2.[5,6] However, these studies are not sufficient for commercial applications of SG solvent. It is crucial to investigate corrosion rate of stainless steel and carbon steel using SG solvent for its commercial applications. Based on the comprehensive literature review, such data is rarely available in an open literature. Therefore, in order to address this research gap, the systematic corrosion studies on aqueous SG solvent have been carried out in this study. The corrosion data on the SG solvent is very useful for the selection of appropriate materials for fabrication of plant and utilities. Besides, the evaluation of a corrosion tendency of SG solvent and its comparison with conventional amine solvents is also a key criterion for the commercial suitability of the SG solvent.

MATERIALS AND METHODS

In this study, weight loss method was used for measuring the corrosion rate. The weight loss method is a simplest and established technique for investigating the general corrosion. This technique is used for long-term exposure of test metal in the solutions. Weighed test specimens are immersed into the test solutions for the particular time, and then removed for determining the loss in weight of the specimen.

Chemicals and gases

There are various chemicals and gases used in this work, such as glycine, sodium hydroxide, monoethanolamine, acetone, and double distilled water. These chemicals were supplied by Merck Sdn Bhd. Malaysia. The gases such as CO_2 and N_2 were supplied by Air products Sdn Bhd. Malaysia. All the chemicals and gases were used without further purification. Double distilled water was used for preparing the samples. The detailed specifications of the chemicals and gases used in this study are summarized in Table I.

TABLE I. Specifications of chemicals and gases

Chemicals / gases	Chemical formula	Purity	Method of purification	Supplier
Glycine	H_2NCH_2COOH	≥ 99%	None	Merck
Sodium Hydroxide	NaOH	≥ 99%	None	Merck
Monoethanolamine	C_2H_7NO	≥ 99%	None	Merck
Water	H_2O	99%	Double distillation	-
Acetone	C_3H_6O	≥ 99.5%	None	Merck
Carbon dioxide	CO_2	99%	None	Air products
Nitrogen	N_2	99%	None	Air products

Preparation of solvent samples

Aqueous solutions of SG were prepared by neutralizing glycine dissolved in double distilled water with an equimolar amount of sodium hydroxide. The solutions were stirred continuously until complete dissolution.[7] All the concentrations of the solutions were prepared in mass fractions, denoted by w. An electronic analytical balance (Sartorius, model BSA-224S-CW) was used for all mass measurements with the accuracy of $\pm 1 \cdot 10^{-4}$ g. The concentrations of solvent were prepared as 0.10, 0.20 and 0.30 mass fraction which are according to the commercial applications for CO_2 removal process. Moreover, the selected concertation range represented the low, medium and high concentration of amino acid salts which are commonly used for systematic investigation of concentration effects on corrosion rate and comparison with literature. In addition, the purpose of selecting these ranges of concentrations of solvents was to avoid the formation of solvent precipitation during CO_2 absorption.[8,9]

Specimen description and preparation

There are two types of a specimen used in this work, stainless steel (SS304) and carbon steel (CS1018). These specimens are also called as corrosion coupons. The coupons can be rectangular, cylindrical, and discs of any dimensions. The dimensions of the test coupons are selected according to the conditions of the tests, and the facilities available for the corrosion testing. Carbon steel and stainless steel are selected in this study because they are widely used in the fabrication of equipment, accessories, and pipelines in CO_2 capture plant.[1] The corrosion coupons were purchased from Metals Samples Inc. USA. The coupons were shipped in individual vapor corrosion inhibition (VCI) bags to prevent the vapor and atmospheric corrosion of the coupons. The coupons are rectangular having dimensions (1/16" thick × 1/2" wide × 3" length). The coupons have 3/16" diameter hole located 1/4" from an end centered with 1/8" radius corners. Besides, all the coupons are pre-weighed, and stenciled with sequential numbers and alloy codes to avoid confusion during exposure. As an example, the coupons used in this study are shown in Fig 1. (a) SS304, (b) CS1018. The chemical composition of the coupons (SS304 and CS1018) is given in Table II.

Fig.1 Corrosion coupons

TABLE II. Chemical composition of corrosion coupon used in this study

	Composition %	
Element	SS304	CS1018)
Carbon (C)	0.0575	0.1900
Manganese (Mn)	1.6540	0.6700
Phosphorus (P)	0.0330	0.0300
Sulphur (S)	0.0010	0.0010
Chromium (Cr)	18.1630	0.0300
Nickel (Ni)	8.0340	0.0400
Copper (Cu)	0.4700	0.0800
Molybdenum (Mo)	0.3370	0.0200
Nitrogen	0.0650	0.0070
Iron (Fe)	Balance	Balance

The specimens were prepared before use by grinding with silicon carbide waterproof abrasive papers of the grit range from 120 to 600, supplied by Saie Brand China. The specimens were then cleaned with deionized water, degreased with acetone, and dried with dry air. Finally, the prepared specimens were stored in the desiccator for corrosion experiments. The prepared specimens were handled carefully with gloves and tweezers to avoid the contamination of the specimen surface. The method of preparing the specimen is followed according to ASTM G1-90 standards.[10] The prepared specimens were used within 24 hours of the preparation.

Weight loss method for corrosion measurement

Corrosion testing using weight loss technique is the simplest and longest-established method to measure the uniform corrosion. In this method, a weighed coupon of the metal or alloy is immersed into the test solution under certain conditions (varies according to the objectives of the study) for the reasonable period, depending upon the experimental objectives and test design. Later, the coupons were removed and cleaned of all the corrosion materials and reweighed. The weight loss in metal was then used for the calculation of corrosion rate.[11,12] In this study, the weight loss technique is used because it is widely used in laboratories, and industries due to a number of attractive features.[12] The corrosion experiments are easy to conduct using weight loss method because no sophisticated or complex instruments are required. The measurement is direct without any theoretical assumption. This technique is applicable to all kinds of corrosion environments, which makes it versatile. Apart from these, it is a low-cost technique, flexible towards experimental facilities available in the laboratories, and allows simultaneous evaluation of various materials, and test solutions at various conditions

of the tests. Despite the oldest method of corrosion measurement, weight loss method is widely used for its sustainable popularity due to versatile features described above.

Experimental procedure

The simple immersion corrosion method was used in this study, and the general corrosion rate was calculated using weight loss method. The fundamental procedure of immersion corrosion tests was followed as per the guidelines of ASTM G-31-72 (Standard Practice for Laboratory Immersion Corrosion Testing of Metals),[11] The requirements of the setup consist of the corrosion bottle (250 mL, Schott Duran), nylon strings (0.45mm, No.2, Ofmer Company) for holding the corrosion coupon, pH meter (SCHOTT instruments), and heating system (hot plate / water bath / oven). In this study, oven was used for the heating purpose. All the corrosion experiments were carried out at an atmospheric pressure. The test solutions were prepared as described in experimental section. The corrosion bottles filled with 250 mL of test solution were purged with CO_2 until the saturation conditions at an ambient temperature. Later, before immersing the coupons into the test solution, the coupons were weighed using analytical electronic balance (Sartorius, model BSA-224S-CW) with an accuracy of ± $1 \cdot 10^{-4}$ g. The corrosion coupons were immersed into the corrosion bottles by hanging with the help of nylon string across the opening of the corrosion bottle. The coupons were suspended, and positioned at the center of the corrosion bottle to ensure the complete immersion of coupons in the test solution, and not to touch the bottom of the bottles. The bottles were then closed with the screw lid firmly.[13] The corrosion bottle was labelled with the name of the test solution, identification of the coupons (type of alloy and coupon number), while the date, and time of immersion were recorded.[11,14,15] Finally, the corrosion bottle was placed in the preheated oven at 303.15 K for the period of 240 hours.[12,13,16] Similarly, other experiments were conducted at 313.15 and 333.15 K for the same exposure time. The range of temperature (303.15, 313.15, and 333.15 K) was selected based on the practical range of absorption temperature in CO_2 capture plants, and in order to study systematic effect of temperature on corrosion rate.[17,18] The time of exposure in these types of experiments can vary from 24 to 240 hours.[19] A short time may give sometimes erroneous results. It is recommended to use longer time (240 hours) in order to get more realistic results.[11-13,18] The selected time duration of 240 hours is sufficient and considered as long exposure time that produce measurable corrosion rate and stable corrosion behavior.[11-13,18] This exposure time is also suggested in ASTM G-31-72.[12] Every experiment was duplicated three times to obtain the reproducible results, and the average results were reported. The results were accurate within ± 10 %.

Post-exposure cleaning of specimens

After completion of the test duration (240 hours), the test bottles were removed from the oven, and the specimens were withdrawn from the bottles. Before cleaning the coupons, their appearance was observed and recorded properly. The variation in the test solutions was also observed. Although these observations are, qualitative but can provide useful information while analysis of the corrosion results. Cleaning the coupons after a test is an important step in corrosion measurement. The procedure for post cleaning of coupons was followed according to ASTM G1-90 standards.[10] The coupons were washed with running tap water, cleaned with the non-metallic brush, and chemically washed. Later, the coupons were scrapped with at least two different grit abrasives until the surfaces were free of the remaining corrosion products. The coupons were then washed with acetone, dried, and weighed using an analytical balance. The cleaning cycles were repeated few times until the constant weight loss was obtained by plotting

the number of cleaning cycles versus a mass.[8] During the post cleaning, care should be taken to avoid the removal of base metal.

Calculation of corrosion rate

The corrosion rate of SS304 and CS1018 in the test solutions was calculated according to ASTM G1-90 (Standard Practice for Preparing, Cleaning, and Evaluation Corrosion Test Specimen). Since the weight loss method was used in this study, therefore, the initial and final weights of the specimen were used for estimating the corrosion rate. Following equation was used to calculate the corrosion rate:[9,10]

$$CR = \frac{K \times W}{A \times T \times D} \quad (1)$$

Where CR is the corrosion rate in mpy, K is the constant factor (5.34×10^5), W is the mass loss in grams, A is the area (3.38) in square inch, T is the time of exposure (240) in hours, and D is the density of alloy (SS304: 794; CS1018: 7.87) in $g{\cdot}cm^{-3}$.

RESULTS AND DISCUSSION

Comparison of corrosion rate of monoethanolamine with the literature

The corrosion rate of 0.30 mass fraction of MEA was measured at various temperatures (303.15, 313.15, and 333.15 K) in order to compare the results with literature. The result of corrosion rate of MEA at 313.15 K was compared with the previous work,[20] since the data is not available in the literature at other temperatures. The comparison is shown in Figure 2. The experimental values of corrosion rate at 313.15 K are in the range of the one reported in the literature for 0.30 mass fraction of MEA at 313.15 K.[20]

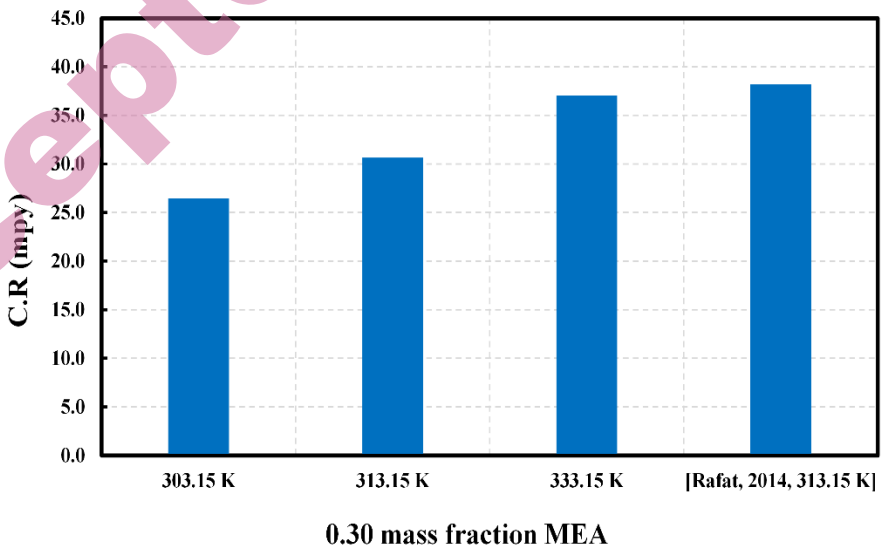

Fig 2. Corrosion rate of 0.30 mass fraction MEA and comparison with literature

Corrosion rate of aqueous SG solutions

The corrosion rate of SS304 and CS1018 in aqueous SG solutions was measured by weight loss technique at three different temperatures (303.15, 313.15, and 333.15 K) followed by various mass fractions (0.10, 0.20, and 0.30). Each experiment is conducted three times, and the average results are reported. The process parameters of interest in this study for corrosion measurement are temperature, concentrations, and type of metallurgy. Therefore, the effects of these parameters on corrosion rate were studied using weight loss technique.

Effect of temperature on corrosion rate

The temperature is essential parameters, which influence the rate of corrosion. Therefore, in this study, the effect of temperature on the corrosion rate of SS304 and CS1018 was investigated at three different temperatures mentioned above. From the analysis of the corrosion results, it was found that the temperature has significant influence on the corrosion rate of both SS304 and CS1018 in the aqueous SG solutions. The rate of corrosion increases with an increase in the system temperature as shown in Fig. 3(a)-(b) below. This suggests that increasing the solution temperature increases the kinetic energy of the species thereby accelerate the iron dissolution, and thus enhances the corrosion rate.[21,22] The corrosion reaction (iron dissolution) is represented by equation 2.

$$Fe + HCO_3^- \rightarrow FeCO_3 + H^+ + 2e^- \quad (2)$$

Moreover, increasing the temperature increases the mobility of reacting species by increasing the diffusion of ions of the reactive species to the metal surface thereby increases the corrosion rate.[4,24] Moreover, passive oxide films may become unstable and more porous at elevated temperature thereby accelerating the iron dissolution process.[21-23] The similar trends are observed for various amine solutions.[3,4,24,25] By further investigating the effect of temperature on the corrosion rate, it was observed from Fig.3(a)-(b) that the effect of temperature from 303.15 K to 313.15 K is less as compared to 313.15 K to 333.15 K for both metallurgies, and at various concentrations. The corrosion rate increased significantly from 313.15 K to 333.15 K, which suggests that the corrosion process is dependent on the temperature. This trend could be due to the reason that the corrosion reaction kinetics increases at high temperature. These trends are same as reported in the literature for various solvents used for CO_2 capture.[3,4,24,25] Moreover, the effect the temperature on the corrosion rate of SS304 is less as compared to that on CS1018 for aqueous SG solutions. This could be due to the reason that SS304 is significantly less corrosive as compared to the CS1018. Therefore, increase in temperature does not affect much on corrosion of SS304 in aqueous SG solutions. At highest studied temperature (333.15 K) and high concentration (0.30 mass fraction), the corrosion rate of SS304 in aqueous SG solutions is 3.291 mpy.

Similarly, the corrosion rate of CS1018 at same conditions is 32.203 mpy in aqueous SG solutions.

Furthermore, the effect of temperature on the corrosion rate of SS304 and CS1018 followed the Arrhenius behavior as given by equation 3.

$$log\ C\ .R = log\ A - \left(\frac{E_a}{2.303 \times R \times T}\right) \quad (3)$$

Where *C.R* is the corrosion rate (mpy), *A* is Arrhenius pre-exponential factor, $E_a/2.303 \times R$ is the slope of the equation, in which E_a is the activation energy (J/mol), and *R* is the universal gas constant (J/K mol), and *T* is the temperature in K. From equation 3, the plot of log C.R versus 1/T gives the straight lines, as shown in Figures 3 (a)-(b). From the Arrhenius plots, the effect of temperature on the corrosion rate of SS304 and CS1018 in aqueous solutions of SG is more obvious.

Moreover, the Arrhenius equation given above can also be used for the prediction of corrosion rate of SS304 and CS1018 in aqueous SG solutions. Therefore, for the validation of experimental results, the corrosion rate data of the studied solvent were also predicted by using equation 3 and its coefficients. The validity of experimental and predicted data was assessed statistically by estimating the deviation between both data. The values of Arrhenius pre-exponential factors (*A*), slope of the lines ($E_a/2.303 \times R$), R^2, and *SD* are given in Table III for aqueous SG solutions.

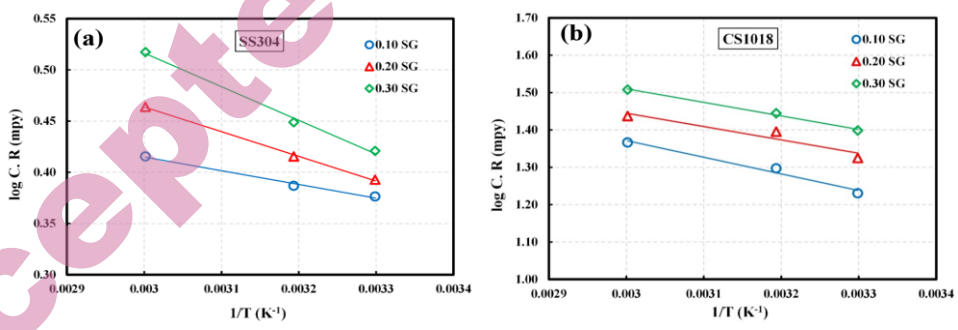

Fig 3. Arrhenius plot (log C.R vs 1/T) for corrosion rate of (a) SS304 (b) CS1018 in aqueous SG solutions at various concentrations

TABLE III. Corrosion rate correlation parameters for aqueous SG solutions

w SG	*Ea/2.303 R*	*A*	R^2	*SD*
		SS304		
0.10	133.72	6.547869	0.9909	0.0088
0.20	240.73	15.34264	0.9984	0.0071
0.30	328.45	31.75411	0.9948	0.0188
		CS1018		
0.10	445.82	511.564	0.9762	0.3802
0.20	357.74	329.6856	0.9048	0.7842
0.30	362.91	397.1001	0.994	0.2195

Effect of concentration on corrosion rate

It is very essential to study the effect of concentration of SG on the corrosion rate of SS304 and CS1018. Different concentrations of the solvent give different corrosion rate of both metallurgies. Therefore, in this study, the corrosion rate of SS304 and CS1018 in aqueous SG solutions was measured at different concentrations (0.10, 0.20, and 0.30 mass fractions). The graphical representation of the effect of concentration on corrosion rate of SS304 and CS1018 in aqueous SG solutions at various temperatures is shown in Fig.4 (a)(b).

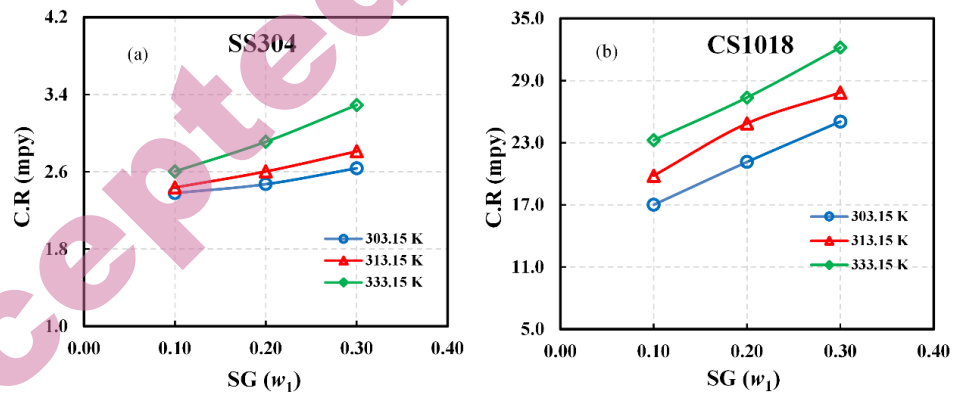

Fig 4. Effect of concentration on corrosion rate of (a) SS304 (b) CS1018 in aqueous SG solutions at various temperatures

From the analysis of corrosion results, it was found that the corrosion rate increases with increasing the concentration of SG in the solution. This trend is due to the reason that when the concentration increases, the absolute amount of CO_2 absorbed increases, which results in the higher number of bicarbonates, and protonated amines. The increasing number of bicarbonates (HCO_3^-) and protonated amines causes the greater rate of iron dissolution, and hence increases the corrosion rate. Moreover, higher concentration also increases the ionic strength and electrical

conductivity thus facilitates the charge transfer and increases the iron dissolution. Additionally, the enhanced concentration of amino acid salts helps to form the metal-amino acid complexes. These complexes formation restrict the development of protective layers onto the metal surface thereby exposing the metal to the reacting species and increases the corrosion.[26,27] The same trend has been observed in the literature for various amines.[20,24] Moreover, the effect of concentration on the corrosion rate of SS304 is much lower than CS1018. This may be due to the reason that SS304 is significantly less corrosive than CS1018. However, the trend still shows the increasing tendency similar to that observed for CS1018. On further analyzing the results, it was observed that at a fixed temperature (303.15 K), the corrosion rate of SS304 in aqueous SG solution increased from 2.379 mpy to 2.636 mpy (10.80 % increase) when the concentration was increased from 0.10 to 0.30 mass fraction. However, the effect of concentration on the corrosion of CS1018 in SG solution is significantly higher than that observed for SS304. At a fixed temperature (303.15 K), about 47.26 % increase in corrosion rate of CS1018 in aqueous SG solution was observed when increasing the concentration from 0.10 to 0.30 mass fraction. From the above facts, it is quite apparent that corrosion rate of CS1018 is largely influenced by the concentration of aqueous SG solutions. On the average, the corrosion rate accelerated to almost 40% when the concentration increased from 0.10 to 0.30 mass fraction. These results suggest that SS304 is corrosion resistant even at high concentrations, while CS1018 is significantly corrosive at high concentration of SG solutions. These results could significantly be used for the selection of appropriate materials of construction of CO_2 capture plants. Moreover, the results also provide the significant guidance to select the appropriate solvent concentration for CO_2 capture process, so that the corrosion problem could be minimized.

Effect of the type of metallurgy on corrosion rate

The appropriate material selection for CO_2 absorption column is very essential because it affects the capital and operational cost of CO_2 capture process.[28] In general, there are two types of metallurgies such as SS304 and CS1018 widely used for the fabrication of CO_2 capture plants.[1,2,4] For every new solvent, it is very important to investigate the corrosion rate of these two materials in the new solvents prior to the solvent selection.[29] Therefore, in this study, the corrosion rate of SS304 and CS1018 in aqueous solution of SG was investigated at three different temperatures (303.15, 313.15, and 333.15 K) and for various concentrations. The comparisons of corrosion rate data of SS304 and CS1018 at various temperatures and concentrations are presented in Figure 5 for aqueous SG solutions.

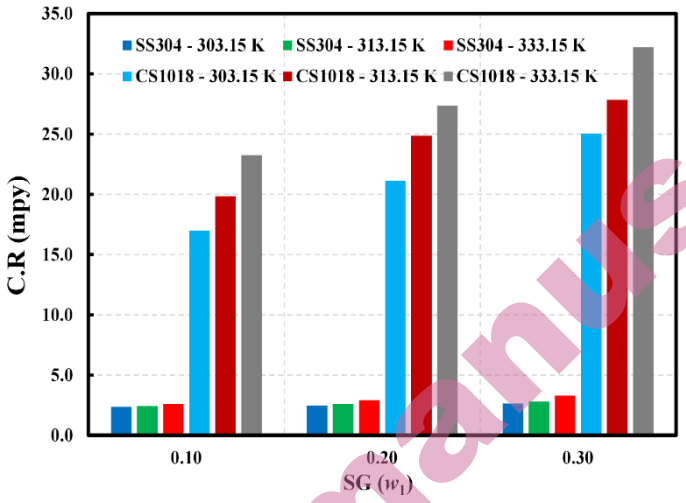

Fig 5. Comparison of corrosion rate of SS304 and CS1018 in aqueous SG solution at various temperatures

From the analysis of the data, it was found that the SS304 is significantly less corrosive than CS1018 as obvious from Figure 5 at various temperatures and concentrations. The highest corrosion rate of SS304 at high temperature (333.15 K) and high concentration (0.30 mass fraction) is 3.291 mpy in aqueous SG solutions. These values of corrosion rates of SS304 are considered as negligible.[24] In other words, it can be said that corrosion rate of SS304 in aqueous solutions of SG is negligible and can be neglected. This evidence suggests that SS304 is highly corrosion-resistant material in aqueous SG solutions. On the other hand, CS1018 is significantly corrosive than SS304. Moreover, the highest corrosion rate of CS10118 at high temperature (333.15 K) and high concentration (0.30 mass fraction) is 32.203 mpy in aqueous SG solutions. Based on this comparative analysis of the two metallurgies, SS304 can be a better material for the construction and fabrication of CO_2 absorption plant than CS1018.[30,31]

The higher corrosion-resistant behavior of SS304 can be attributed to the fact that under the test conditions of this study, the SS304 did not significantly undergo the active dissolution process, whereas, CS1018 is in the active dissolution process. The alloys like SS304 can easily form the passive films (chromium oxide), which offer the corrosion protection of this material.[24] Initially, during the immersion of corrosion coupons specimen in the test solutions, these specimens are clean and film free, and exposing these fresh test specimens with more anodic and cathodic sites to the aqueous SG solution favors the corrosion process.[24] Since, the passive film layer on SS304 surface is more readily formed, therefore, no severe dissolution occurs even after the long immersion time. The formation of passive films suppressed the iron dissolution process, thereby reducing the

corrosion rate.[32-34] Whereas, in case of CS1018, the active dissolution process continues until sometime, and passive films do not form readily, and until the time much dissolution takes places, which results in the more corrosion rate of CS1018. This suggests that passive films formation plays crucial role in corrosion protection.[32,34,35] In this study, passive films on CS1018 are not formed therefore more corrosion rate was observed for CS1018. The similar trends of corrosion behavior of SS304 and CS1018 in aqueous amine solvents are observed, and reported elsewhere.[17,18] The above findings endorse that SS304 is the superior and preferred material of construction for the fabrication of CO_2 capture plant and accessories as compared to CS1018.

Comparison of corrosion rate of the solvents

The corrosion rates of various solvents studied in this work are compared in terms of their performance towards the corrosion protection. It is very crucial to analyze, and compare the corrosion tendency of various solvents to be used for CO_2 capture. Since, the alloy like SS304 is considered as slightly corrosive, therefore, the comparison is only made for corrosion rate of CS1018 in the solvents such as SG, MEA, MDEA, and DEA. Moreover, since the data on corrosion rate of CS1018 in amine solvents is also very scarce and scattered, therefore, a possible comparison of corrosion rate in the solvents studied in this work is made with the amine solvents at 313.15 K. Fig 6. shows the comparison of corrosion rates between various solvents. The concentration of the solvents is taken as mass fraction. From the Fig 6. it is apparent that the solution of SG is less corrosive as compared to amine-based solvents. Among the amines, DEA has lower corrosion rate as compared to other amines, however, still higher than amino acid salts. Aqueous SG solution has less corrosion rate than MEA and DEA. From the above observations, the corrosion rate of the solvents shown in Fig 6. follows the trend in the order of corrosion rate such that MDEA > MEA > DEA > SG respectively. These results suggest that aqueous amino acid salts could potentially be used for CO_2 capture from various streams of the gas. The comparative analysis of the corrosion data of different solvents will help the design engineers, and corrosion consultants in the selection of appropriate material of construction for the fabrication of CO_2 absorption plant and accessories.

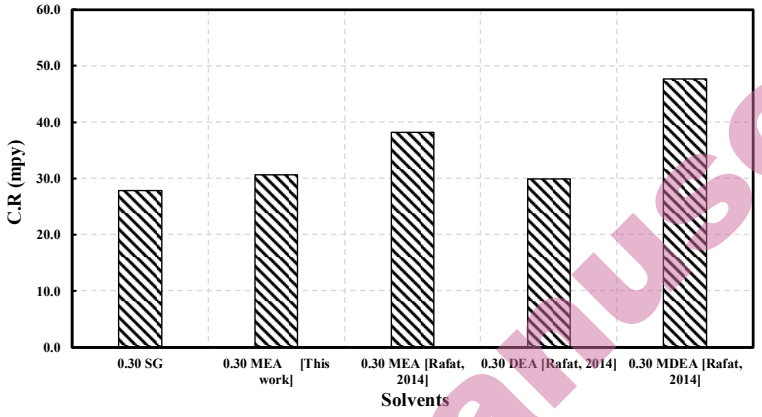

Fig 6. Comparison of corrosion rate of different solvents at 313.15 K

CONCLUSION

The corrosion study of two metallurgies SS304 and CS1018 in aqueous SG solutions was carried out at different temperatures (303.15 K, 313.15 K and 333.15 K) and concentrations (0.10, 0.20 and 0.30 mass fractions). The measured corrosion rate of SS304 and CS1018 in aqueous SG solutions showed increasing trend with increasing the temperature and concentration. The effect of temperature on corrosion rate of SS304 was marginal; however, this effect was significant on CS1018. Similar to the temperature effect, the concentration effect on SS304 was also trivial, but significant in case of CS1018. The corrosion rate data of aqueous SG solutions were correlated by Arrhenius type equation, and good agreement was found between predicted and experimental data shown by lower values of estimated standard deviation (SD). Therefore, the Arrhenius type correlation can be used for the prediction of corrosion rate of SS304 and CS1018 in various solvents. Moreover, it is worth mentioning that SS304 was quite less corrosive, hence, SS304 can be considered as non-corrosive. However, CS1018 was considerable corrosive in the studied solvents. The corrosion rate of various solvents was compared, and followed the order such that MDEA > MEA > DEA > SG respectively. Overall, the solvent studied in this work showed less corrosion than the amine solvents. Therefore, these solvents could potentially be used for the commercial applications of CO_2 removal. Additionally, the corrosion rate data obtained in this study can significantly be used for the appropriate selection of the solvents for CO_2 capture, and materials of construction for the fabrication of CO_2 absorption plant and accessories. Additional notable contribution of present work is an investigation of corrosion rate of the metals in aqueous SG solution using different metallurgies such as SS304 and CS1018 at various temperatures. This provides a large corrosion database, which would help the design engineers, and corrosion consultants in the selection of appropriate material of construction for

the fabrication of CO_2 absorption plant and accessories. Moreover, reported experimental data on corrosion rate will also guide in the selection of appropriate solvent for CO_2 capture.

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И З В О Д

СТУДИЈЕ КОРОЗИЈЕ НЕРЂАЈУЋЕГ ЧЕЛИКА И УГЉЕНИЧНОГ ЧЕЛИКА У ВОДЕНИМ РАСТВОРИМА НАТРИЈУМ-ГЛИЦИНАТА КОЈИ СЕ КОРИСТЕ ЗА ХВАТАЊЕ CO_2

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Корозија је добро познат и озбиљан проблем у процесу апсорпције угљен-диоксида (CO_2), што узрокује огромне трошкове одржавања за санацију кородиране опреме и цевовода. Водени раствор натријум-глицината (НГ) је потенцијални растварач за хватање CO_2. Студија корозије НГ растварача је веома важна за његову практичну примену, јер су такви подаци веома ограничени у доступној литератури. Стога, да би се решио овај значајан јаз, у овој студији су испитане брзине корозије нерђајућег челика (SS-304) и угљеничног челика (CS-1018) применом методе губитка тежине коришћењем НГ растварача на три различите температуре (303,15, 313,15 и 333,15 K) и концентрације од индустријског значаја (0,10, 0,20 и 0,30 масени удео). Резултати су показали да је SS304 показао занемарљиву корозију у НГ растварачу са маргиналним утицајем температуре и концентрације. Међутим, значајан утицај температуре и концентрације је примећен на брзину корозије CS1018 у НГ растварачу. На највишој проучаваној температури од 333,15 K и високој концентрацији (0,30 масени удео), брзина корозије SS304 и CS1018 у НГ растварачу је 3,291 mpy и 32,203 mpy, редом. Штавише, брзина корозије CS1018 у НГ растварачу је упоређена са метилдиетаноламином (MDEA), моноетаноламином (MEA) и диетаноламином (DEA). Утврђено је да НГ растварач показује мању корозивност од различитих аминских растварача. Резултати ове студије пружају смернице за практичну примену НГ растварача у процесу хватања CO_2. Такође, добијени подаци би могли значајно помоћи инжењерима пројектантима да успоставе одговарајуће радне услове процеса хватања CO_2 како би се контролисала корозија.

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