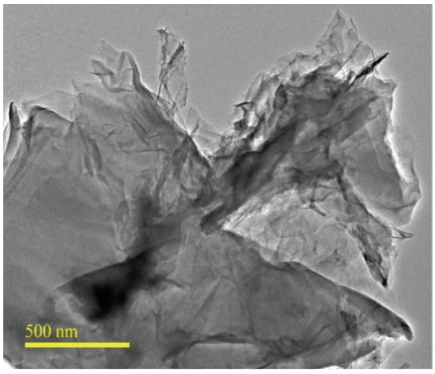

FIGURE 2 TEM image of the prepared diaminododecane as an example.

Results

Characterization

Figure 2 depicts the transmission electron micrograph (TEM) of the diaminododecane-modified graphene. The TEM pictures reveal the flake-like form and wrinkled features typical of GO sheets. At increased magnification, GO's folded and crumpled shape, which is connected to the oxygen-containing functional groups on the surface of GO,[14] could be made out. The folded and crumpled morphology is more obvious in the GO modified with diaminodecane and diaminododecane. This results from the amino functional groups of the functionalized GO forming hydrogen bonds with one another.[15]

Weight-Loss Measurement

Table 2 displays the weight-loss findings for GO treated with diaminodecane and diaminododecane test solutions at high temperatures. The corrosion rate was calculated using Equation 1:

$$Corrosion\ rate(mm/year) = \frac{W \times 8.76 \times 10^4}{A \times T \times D} \quad (1)$$

where W refers to the average weight loss in grams (g), A refers to the total exposed surface area in square centimeters (cm^2), T refers to immersion time in h, and D refers to coupon density in grams per cubic meter (g/cm^3).

Percent inhibition efficiency or %IE was calculated using Equation 2:

$$\%IE_{Wt\ Loss} = \frac{CR_o - CR_I}{CR_o} \times 100 \quad (2)$$

CR_o and CR_I are the corrosion rates for the blank solution and inhibited test solution, respectively.

The modified GO-inhibited solution corroded at a slower rate than the blank. Exfoliated GO nanosheets tend to stay together by π to π stacking, generating large graphite oxide nanosheets. The grafting of diaminoalkanes on the GO surface stabilizes the GO nanosheets, improving GO performance as indicated by the modified GO, as shown in Table 3, having a lower rate of corrosion than the blank. The corrosion rate values for both modified GO-inhibited solutions were lower than blank.

The inhibitor can be adsorbed on metal or steel surfaces through electrostatic attraction/physical mechanism (physisorption) when the protonated inhibitor molecule has an interaction with adsorbed negative chloride ion or organic species on the metal surface. Chemical mechanism (chemisorption) can be undergone when the heteroatom in inhibitor molecules donate lone pair/π-electrons from O (oxygen atom) to the vacant 3d-orbitals of (Fe) metal of the steel.[15]

TABLE 2 DATA SHEET FOR 5% MSA

Coupon	Inhibitor Name	Wt. Before (g)	Wt. After (g)	Inhibition
192	None	12.0176	11.076	
193	G1	11.9466	11.007	92.14 %
194	G2	12.0032	11.052	92.08 %

TABLE 3 DATA SHEET FOR 5% MSA + 5% HCL

Coupon	Inhibitor Name	Wt. Before (g)	Wt. After (g)	Inhibition
196	None	11.9621	10.031	
197	G1	12.0341	10.671	88.67 %
198	G2	12.0079	11.499	95.76 %

Conclusions

The study used diaminodecane and diaminododecane functionalized GO to mitigate carbon steel corrosion in acid solutions (simulate oil well acidizing environment). Graphite powder was used to create the GO. The results showed that the diaminodecane- and diaminododecane-modified GO demonstrated high inhibitory efficiency at high temperatures. Because the GO was created from scrap graphite, this work offers the added benefit of solving both corrosion and waste disposal issues.

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BADER GHAZI ALHARBI is petroleum engineering specialist with Saudi Aramco in Dhahran, Saudi Arabia, email: alharbbg@aramco.com. He joined Saudi Aramco EXPEC Advanced Research Center in 2006 as a petroleum engineer. He has authored and coauthored more than 50 technical papers. He has 10 granted patents and more than 40 submitted invention disclosures. He received his Ph.D. in petroleum engineering from Heriot-Watt University, Edinburgh, Scotland, U.K.

NORAH ALJEABAN is a petroleum scientist with Saudi Aramco in Dhahran, Saudi Arabia, email: norah.aljeban@aramco.com. She focuses on well stimulation and mitigation of scale and corrosion in oil and gas wells. She has a master's degree in polymer science from King Abdullah University of Science and Technology.

AHMAD SAMI BUSALEH is senior lab technician with Saudi Aramco in Dhahran, Saudi Arabia, email: ahmad.busaleh@aramco.com. He joined Saudi Aramco EXPEC Advanced Research Center in 2014 as a lab technician. He has coauthored more than 20 technical papers. He received his associate degree in industrial chemistry technology from Jubail Industrial College.

TAWFIK A. SALEH is a professor at King Fahd University of Petroleum and Minerals in Dhahran, Saudi Arabia, email: tawfik@kfupm.edu.sa. MP