Green Corrosion Inhibitors

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Research Objectives

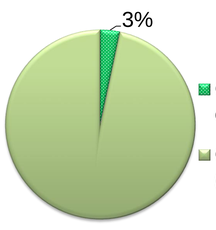
❖ Corrosion is a destructive attack of a metal by chemical, biological and environmental agents [1,2].

Metal sheeting corrosion

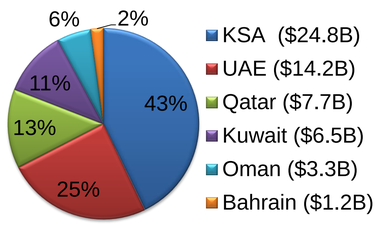
Rusting of an old car

Sinking of 'Erika'

❖ The global cost of corrosion was estimated to be US $2.5 trillion in 2013, equivalent to 3% of global GDP [3].



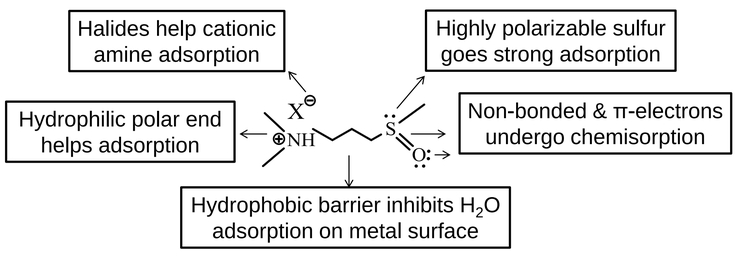
Global cost of corrosion (2013)



GCC cost of corrosion (2011)

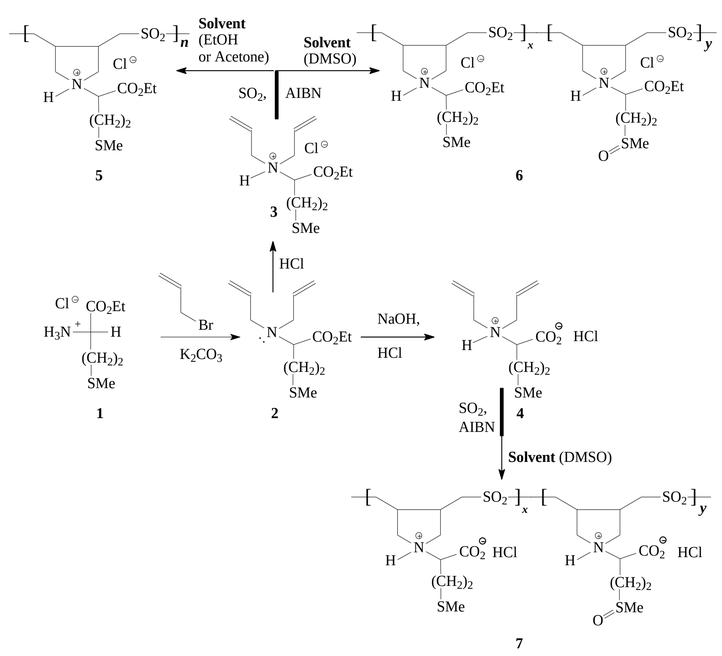
❖ The total annual cost of corrosion for GCC states was appraised to be US $57.96 billion in 2011 [4].

❖ Multi-functional repeated attachment points render polymers very effective inhibitors in corrosive environments [5].



❖ Some polymers having amino acid residue of methionine have been synthesized as green corrosion inhibitors.

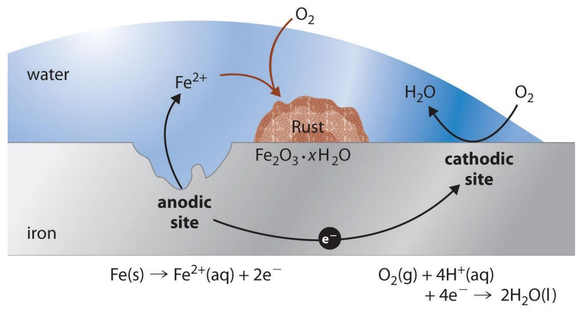
Polymer Synthesis



❖ The polyelectrolytes **6** and **7** were characterized by FT-IR, and NMR; Thermal stability determined by TGA.

Corrosive Reactions in Acid Media

❑ Anodic destruction of an iron metal in acidic media.



❖ The more the amount of oxygen and protons (depolarizer), the worse the deterioration in properties of the metal.

❖ The polymeric inhibitors may block the anodic, cathodic or both half-cell reactions.

Inhibition Efficiency

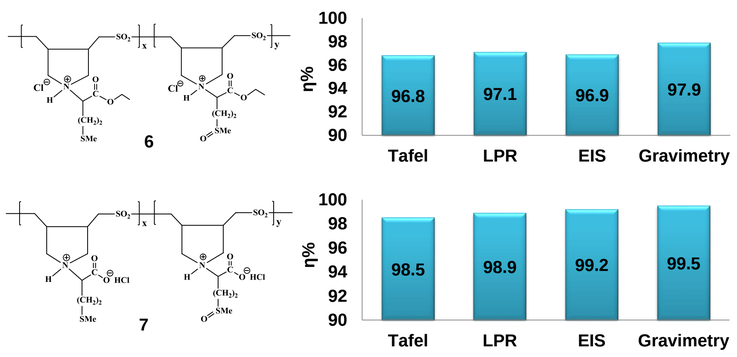
❑ Inhibition efficiencies (η%) of compounds **6** and **7** measured by electrochemical and gravimetric methods.

Sample	Conc. (μM)	Efficiency (η%) Tafel	LPR	EIS	Gravimetry	E_{corr} vs. SCE (mV)
Blank	-	-	-	-	-	-485
6	1.75	77.4	68.0	73.0	78.6	–483
	4.85	84.9	78.6	85.0	83.7	–476
	8.75	89.0	85.1	88.5	86.3	–481
	17.5	90.7	91.5	91.6	89.1	–486
	26.2	92.2	93.8	93.7	94.5	–490
	35.1	94.5	94.4	95.3	95.8	–491
	70.2	96.6	95.3	96.3	97.4	–492
	175	96.8	97.1	96.9	97.9	–494
7	1.75	78.0	70.5	75.1	80.1	–428
	4.85	91.3	81.7	86.5	84.6	–410
	8.75	94.3	88.3	91.3	91.5	–419
	17.5	96.0	93.1	93.6	96.2	–416
	26.2	97.1	98.3	96.6	98.0	–419
	35.1	97.8	98.5	98.2	98.7	–432
	70.2	98.1	98.6	98.9	99.3	–427
	175	98.5	98.9	99.2	99.5	–436

❖ The increase in the inhibitor concentrations increases the inhibition efficiencies (η%).

Comparative η% (175 μM)

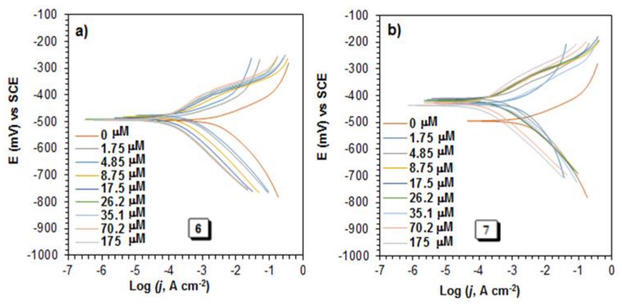
❑ Inhibition efficiencies (η%) of compounds **6** and **7** obtained by different methods at 175 μM.



❖ Exploitation of different corrosion measurement techniques provided coherent inhibition efficiencies.

Polarization Curves

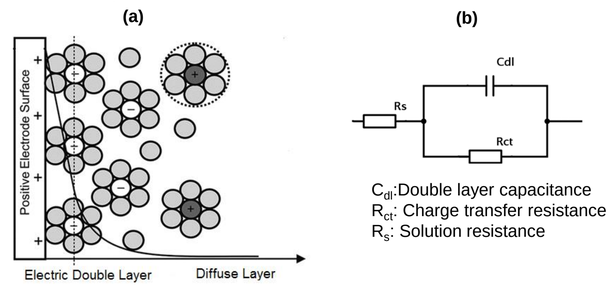
❑ Corrosion potential (E_{corr}) vs. current density (j) curves of compounds **6** and **7** from Tafel extrapolation method.



❖ The direction of E_{corr} in different concentrations for **6** and **7** is suggestive to mixed type inhibition.

Metal/Solution Interface

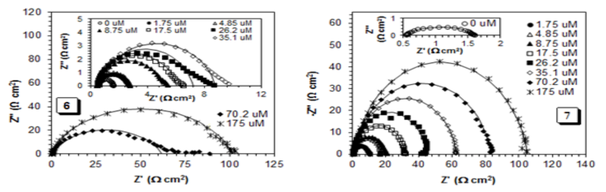
❑ (a) Electrical double layer at the metal/solution interface (b) Randles equivalent circuit used to model the interface.



❖ Electrical double layer (edl) is known to be the origin of the potential difference across the metal/solution interface.

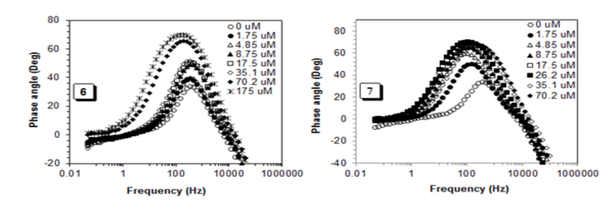
Impedance Measurements

❑ Imaginary impedance (Z'') *vs.* Real impedance (Z') [Nyquist Plots] of compounds **6** and **7.**



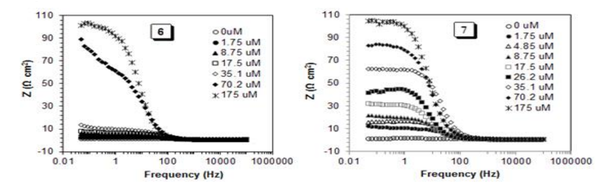
❖ High frequency and low frequency intercepts at real axis (Z') are solution and charge transfer resistances accordingly.

❑ Phase angle (θ) *versus* frequency (ω) curves [Bode Plots] of compounds **6** and **7.**



❖ Increasing maximum angle values at medium frequencies indicates the increase in surface thickness of the mild steel.

❑ Impedance (Z) *vs.* frequency (ω) curves [Impedance Plots] of compounds **6** and **7.**

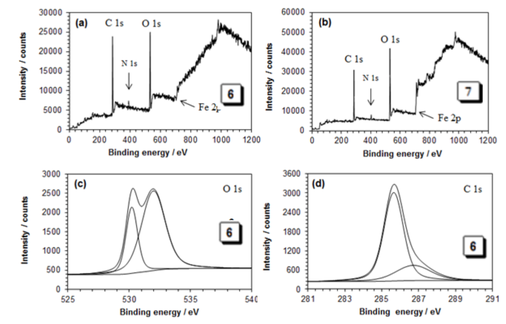


❖ Increase in inhibitor concentration has no effect on solution resistance as evident from horizontal plateau region at high frequency.

❖ However, charge transfer resistance obtained from Z values at low frequency increases with increasing concentration.

X-Ray Photoelectron Spectroscopy

❑ XPS spectrum of (a) **6** and (b) **7;** and XPS deconvoluted profiles of (c) O 1s and (d) C 1s of **6**.



❖ The C, O and N contents detected by XPS ascertain the formation of polymer film on the metal surface.

Conclusions

❖ Two novel polyelectrolytes containing amino acid residue of methionine have been designed and synthesized as green corrosion inhibitors.

❖ Both the inhibitor molecules **6** and **7** demonstrated excellent inhibition efficiencies measured by different techniques.

❖ At a concentration of 175 μM, inhibitors **6** & **7** imparted maximum efficiencies of 97.9% and 99.5%, respectively.

❖ Larger negative value of ΔG°_{ads} than ΔG°_{mic} demonstrated that adsorption favored over micellization.

❖ The XPS study confirms the film formation at the metal surface.

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