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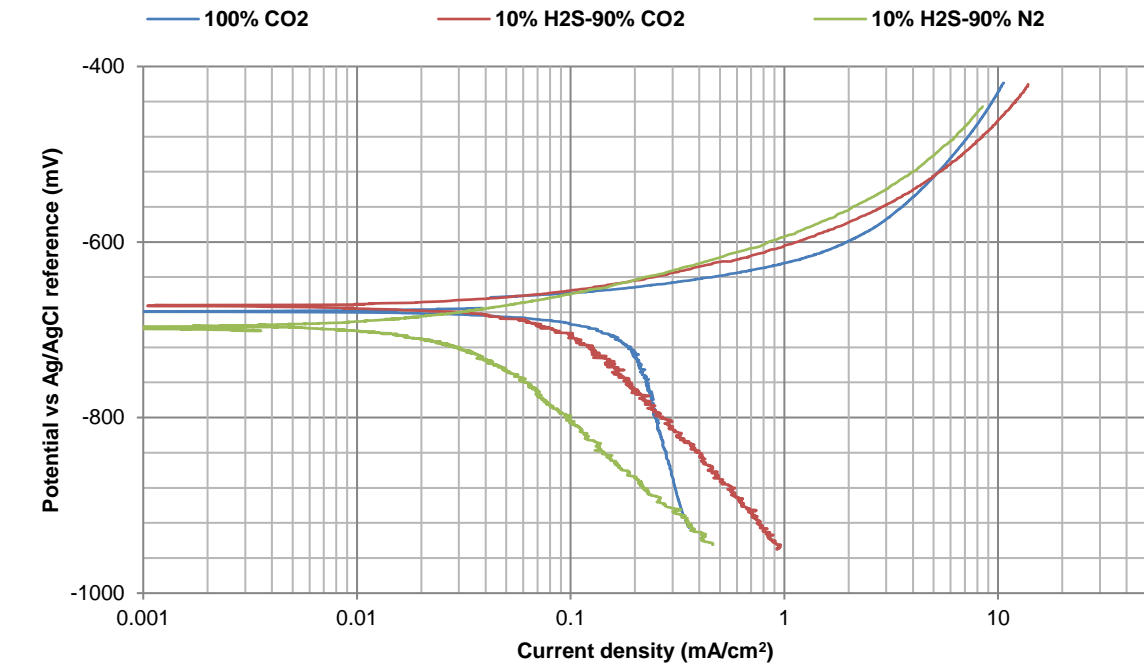
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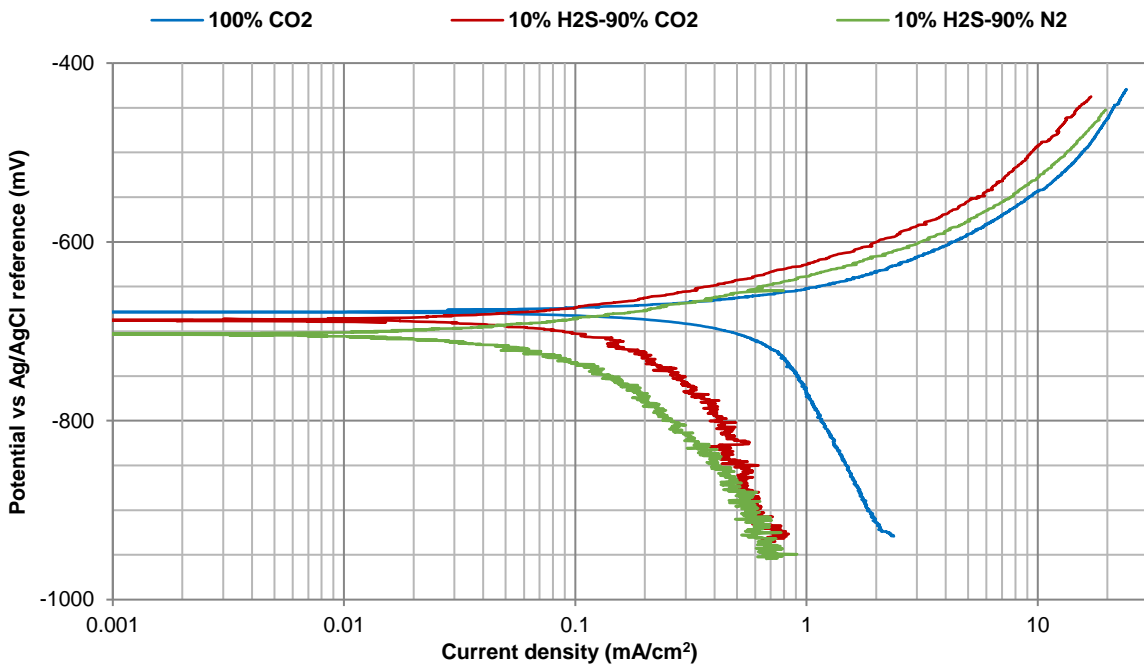
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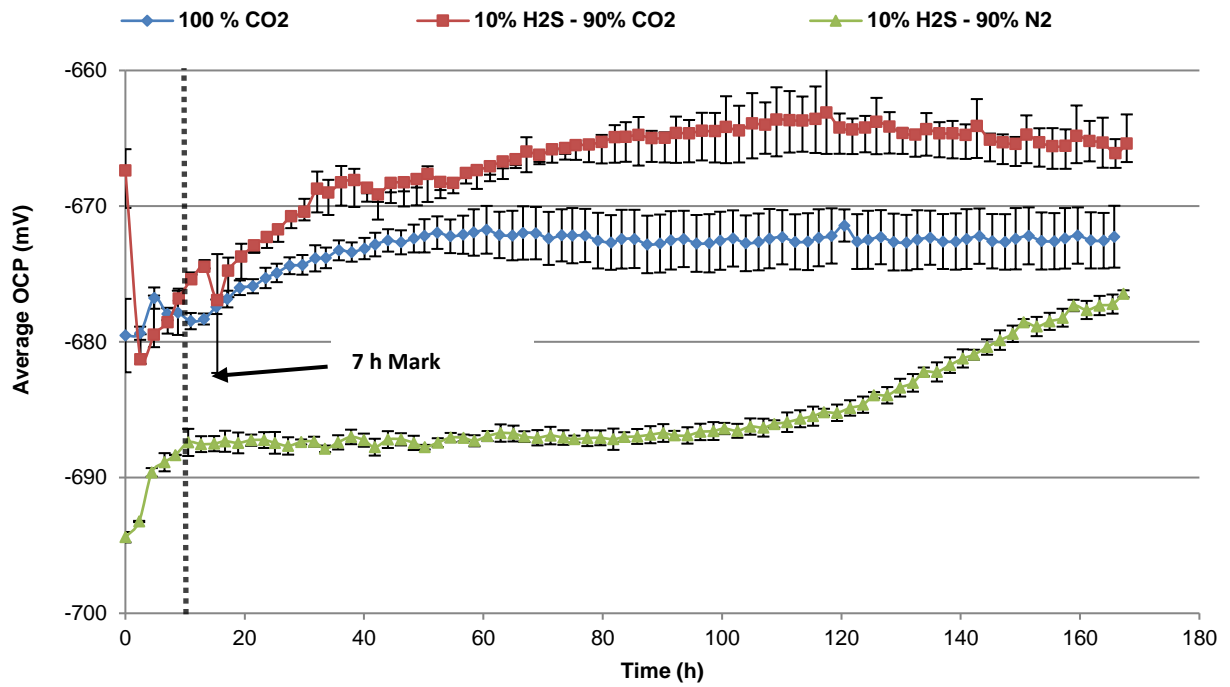


**A**

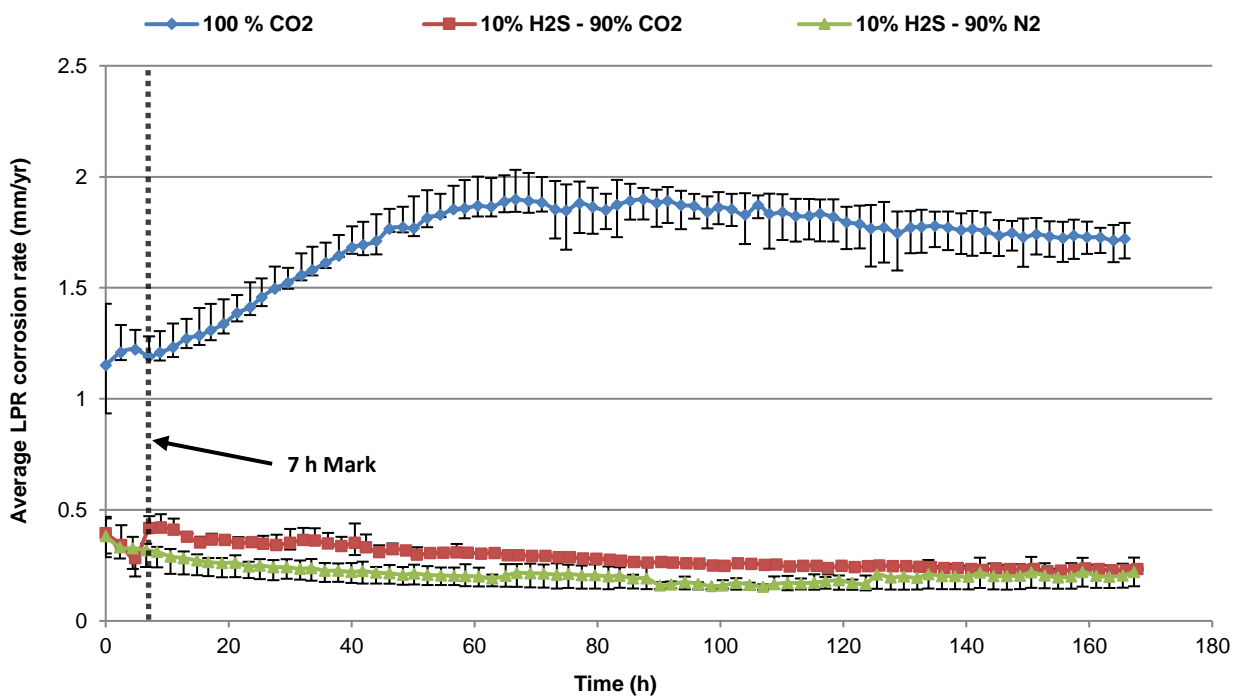


**B**

FIGURE 1: Tafel polarization plots for X65 carbon steel in 3.5 wt.% NaCl solution saturated with 100 mol.% CO<sub>2</sub>, 10 mol.% H<sub>2</sub>S-90 mol.% CO<sub>2</sub> and 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at (a) 30°C and (b) 80°C after 7 h exposure.

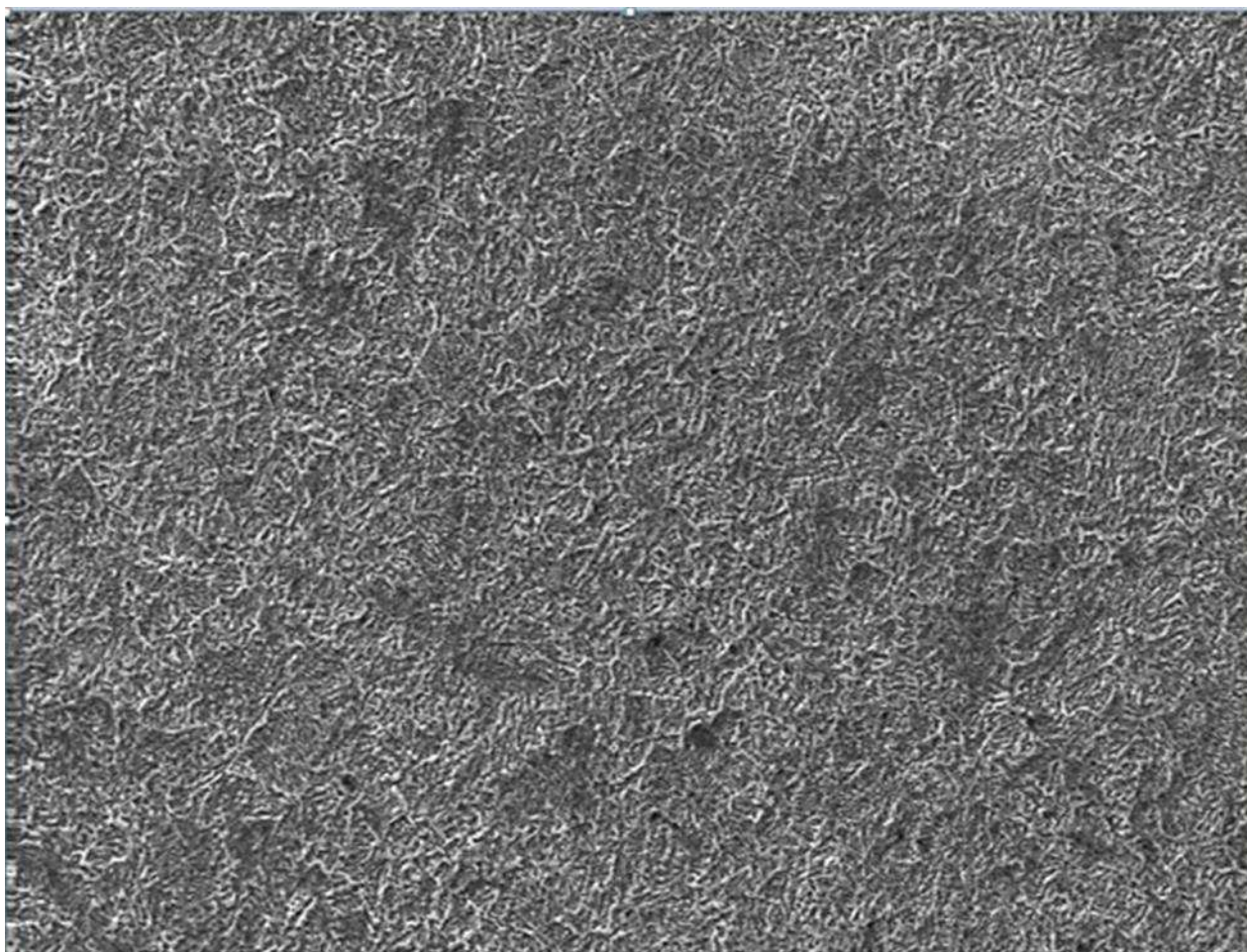


**A**



**B**

Figure 2: Graphs of (a) corrosion potential and (b) corrosion rate of X65 carbon steel in 3.5 wt. % NaCl solution under three different gas atmospheres at 30°C, over 168 h.



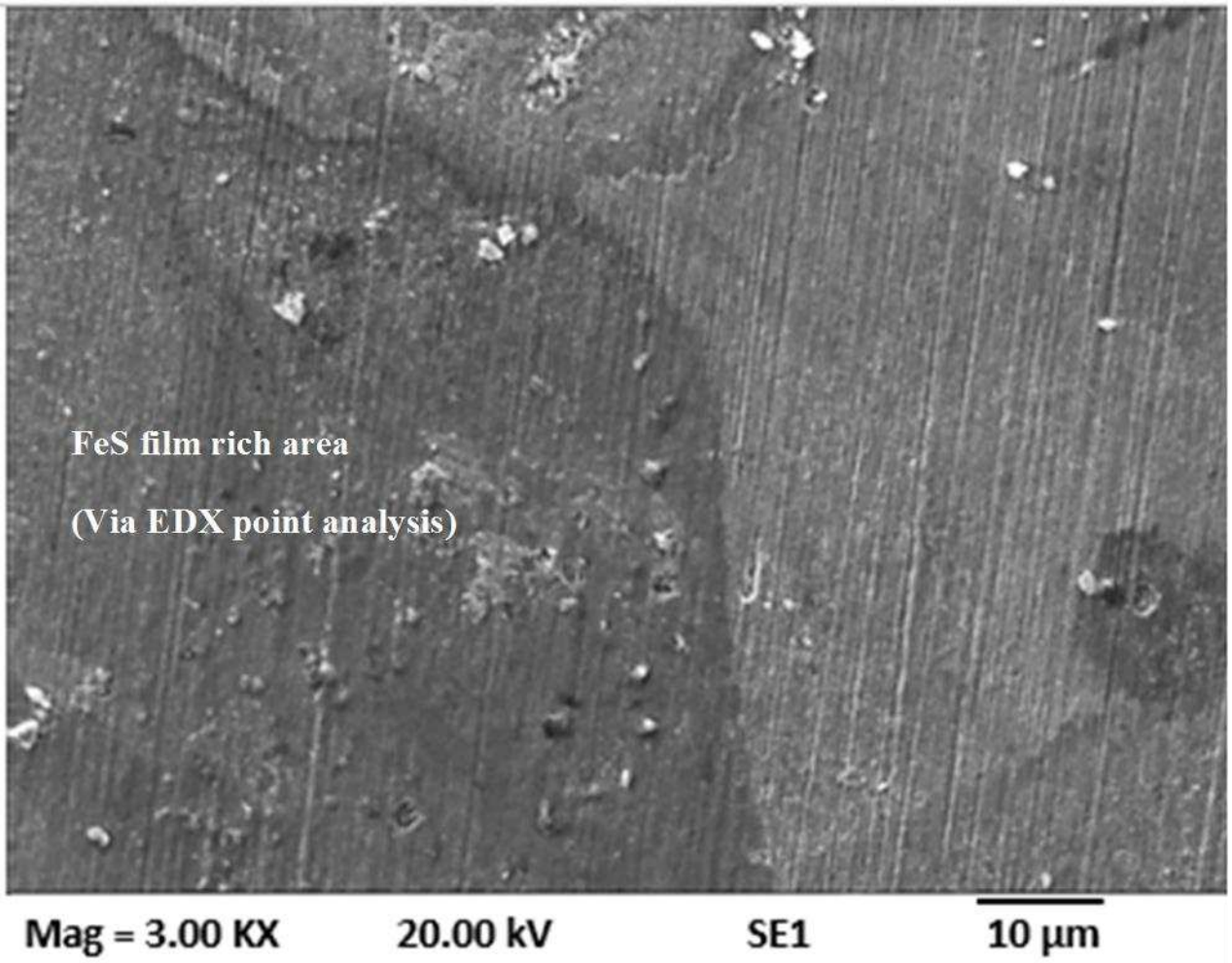
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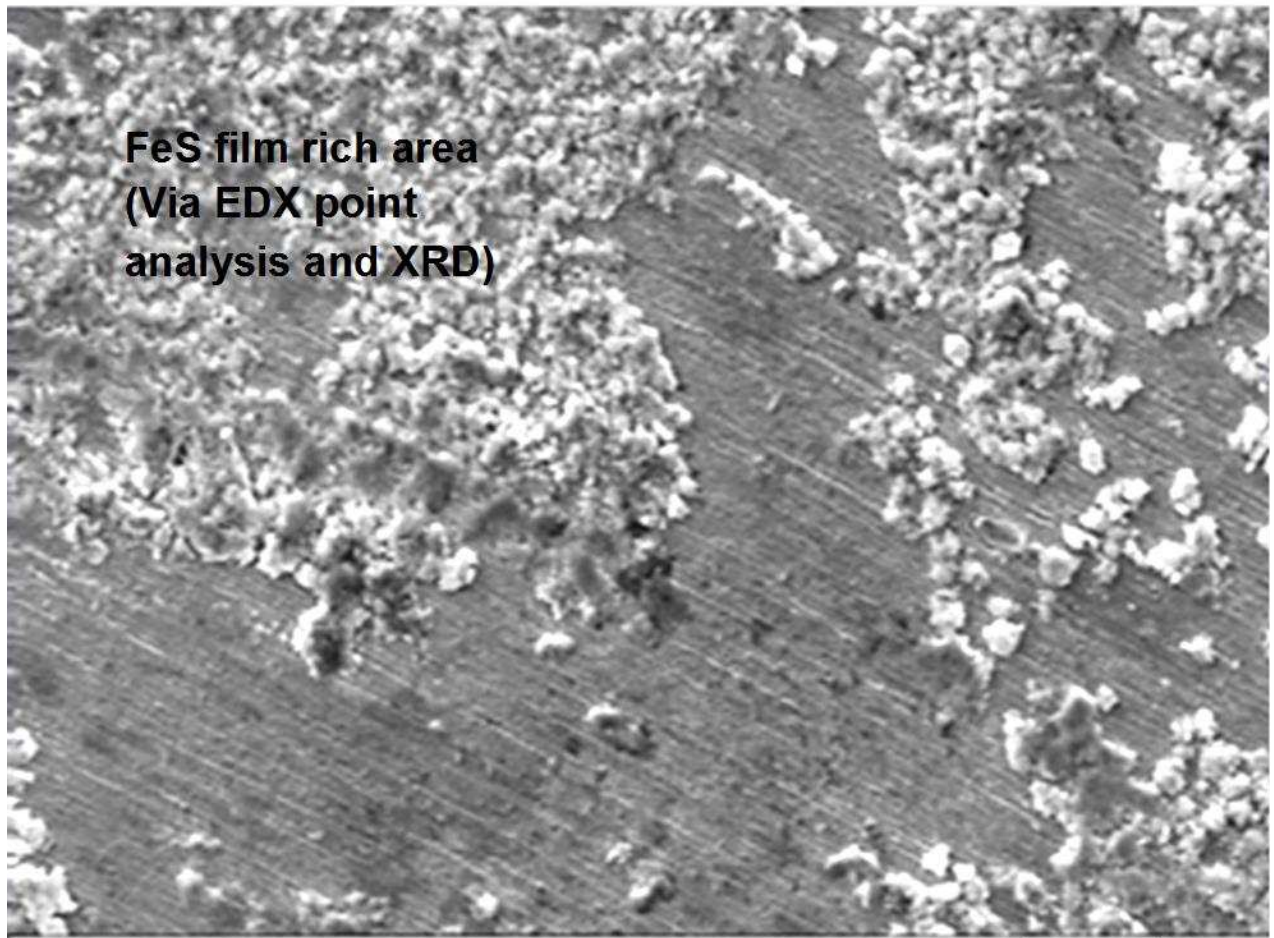
SE1

10  $\mu$ m

A



**B**



Mag = 3.00 KX

20.00 kV

SE1

10  $\mu$ m

C

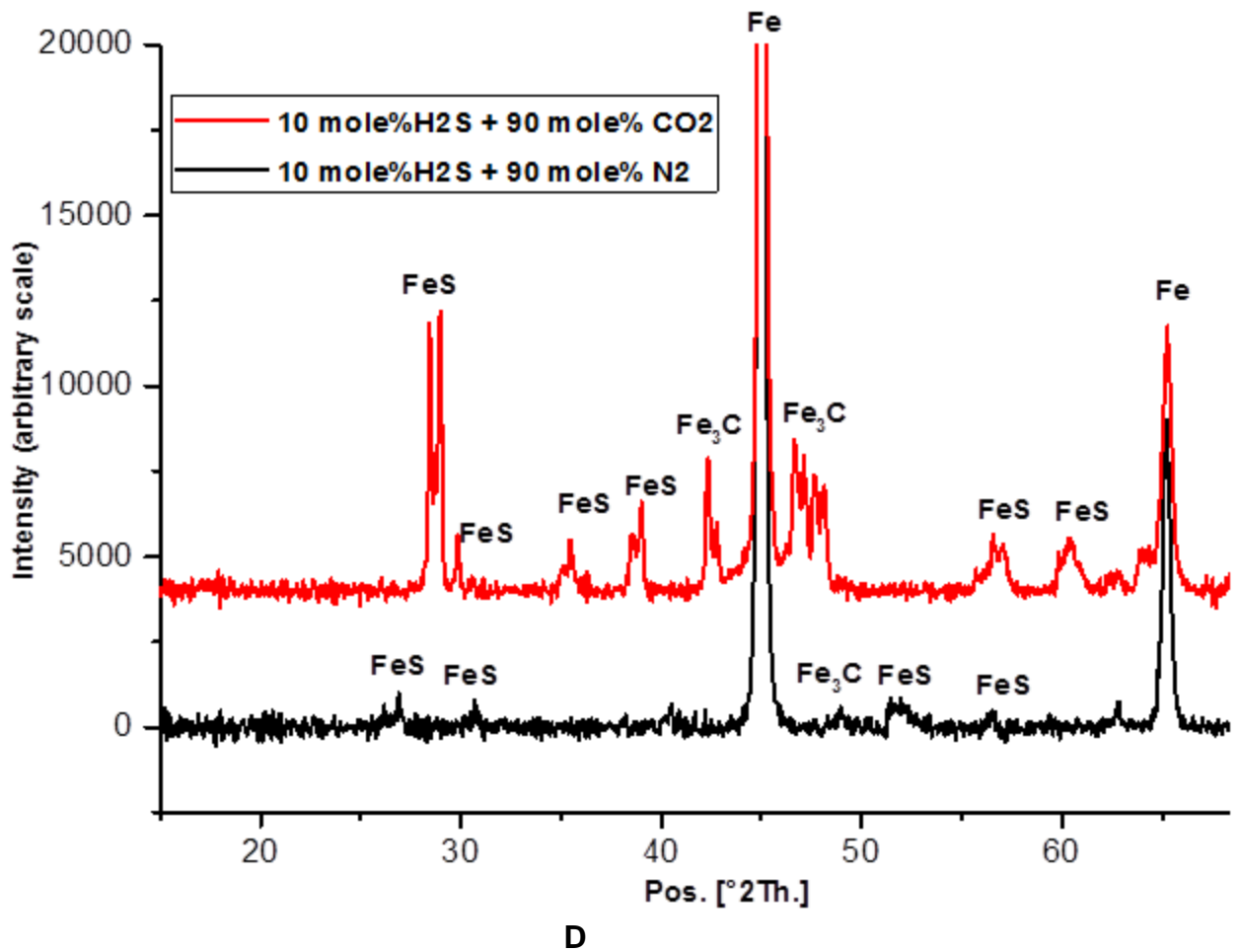
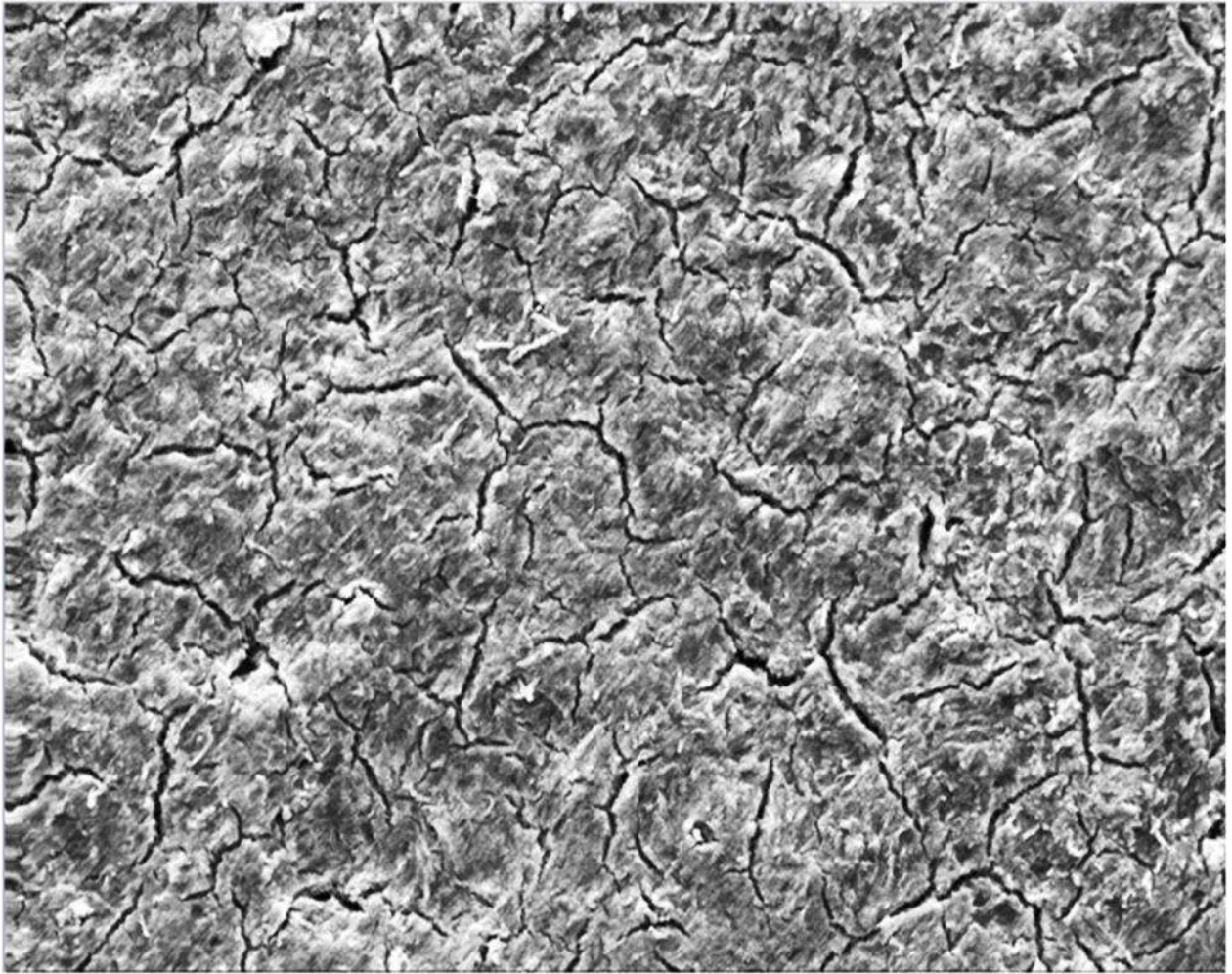


Figure 3: SEM images of corrosion product layer on X65 carbon steel in 3.5 wt.% NaCl solution saturated with (a) 100 mol.% CO<sub>2</sub>, (b) 10 mol.% H<sub>2</sub>S- 90 mol.% CO<sub>2</sub> and (c) 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at 30°C. (d) XRD pattern for corrosion product layer on X65 carbon steel in 3.5 wt.% NaCl solution saturated 10 mol.% H<sub>2</sub>S- 90 mol.% CO<sub>2</sub> and 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at 30°C. Images are for test duration of 7 h. (Note that the intensity scale is arbitrary).



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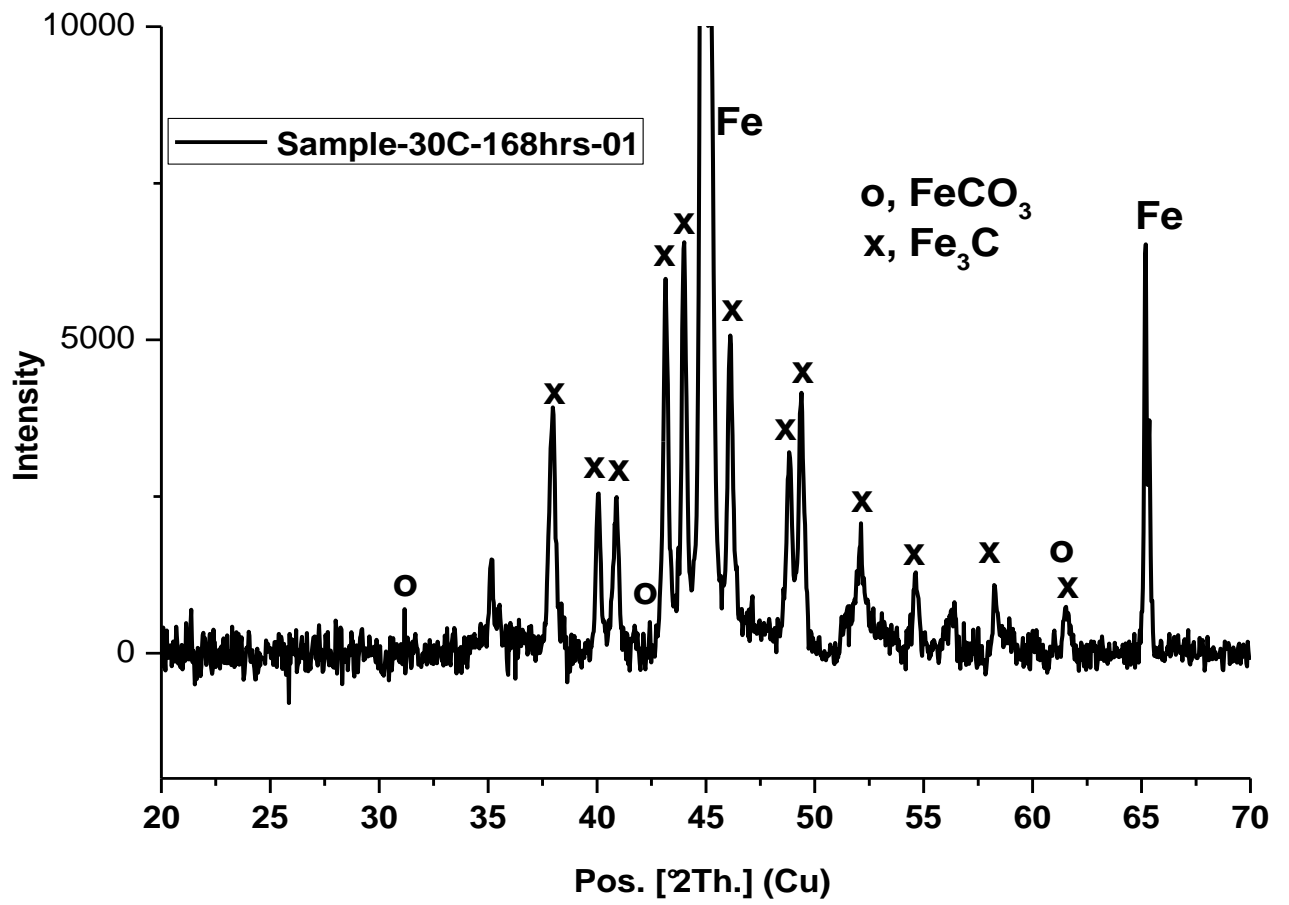
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SE1

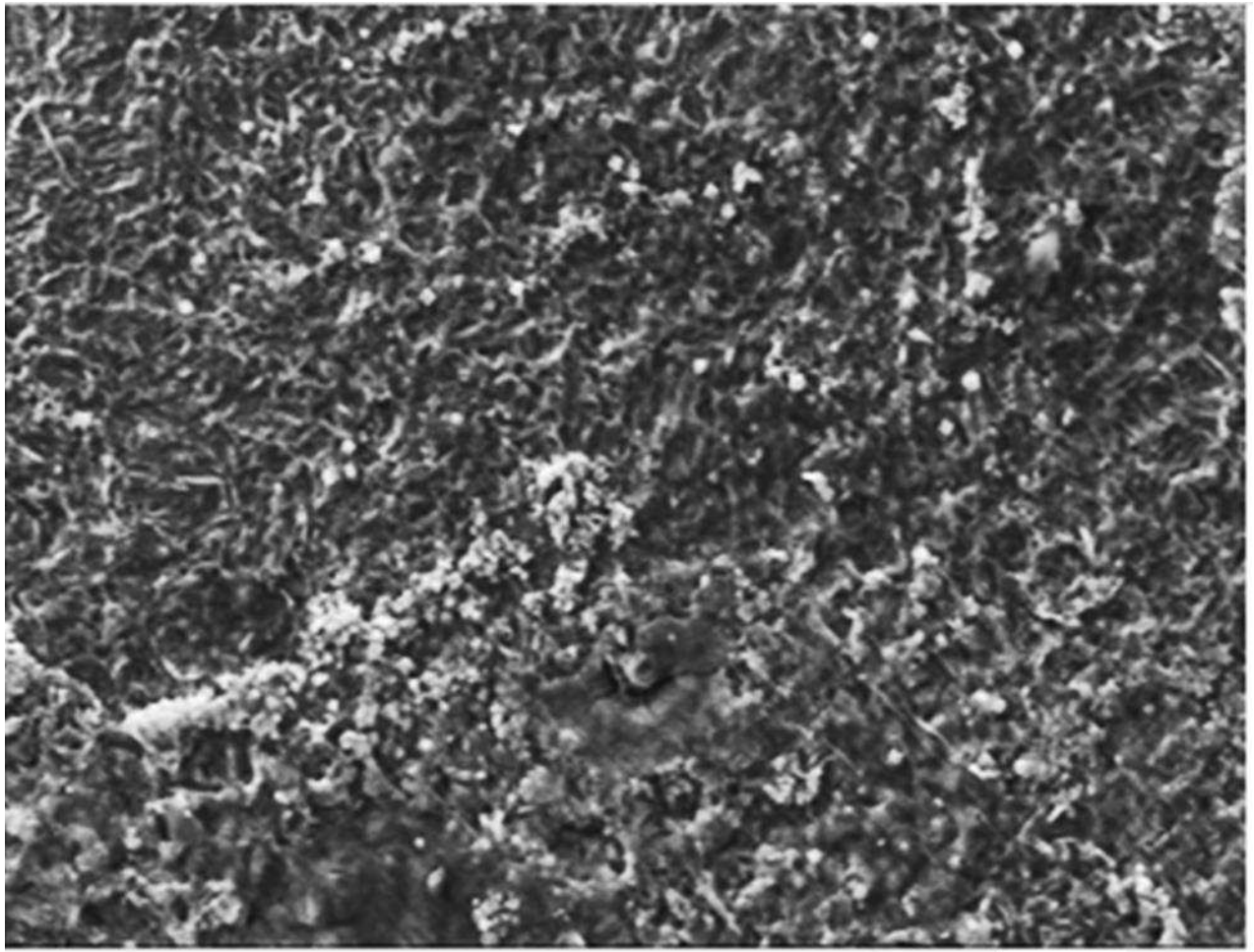
10  $\mu$ m

A





B



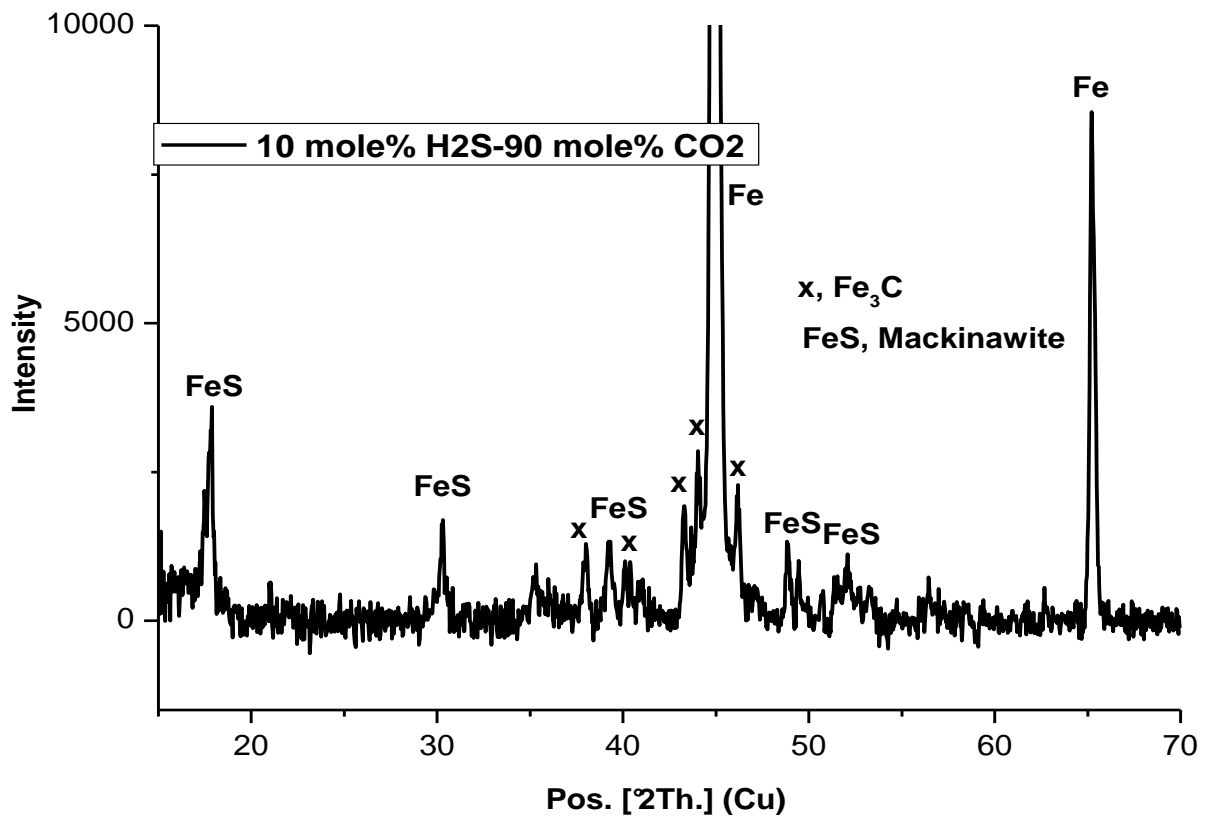
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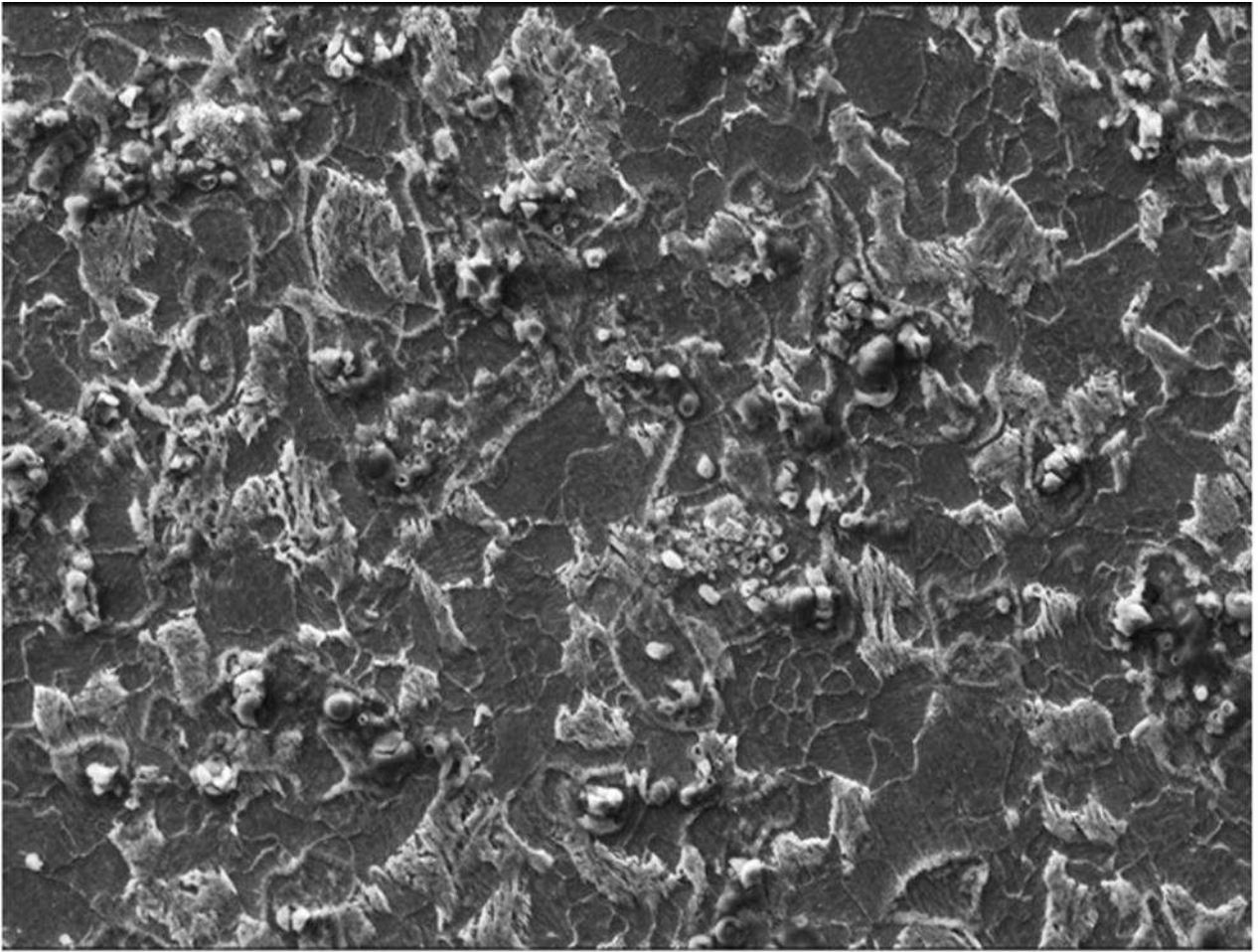
20.00 kV

SE1

10 μm

C





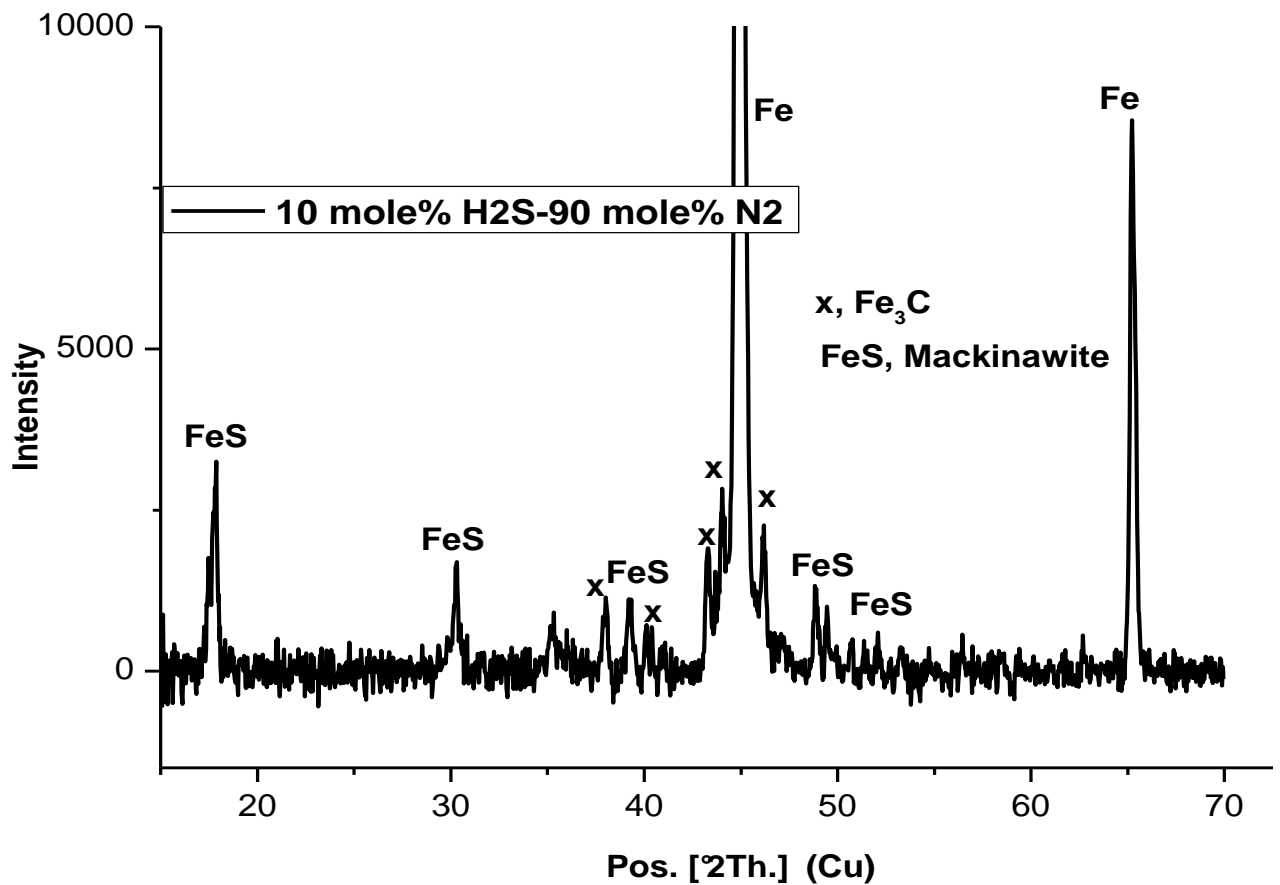
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SE1

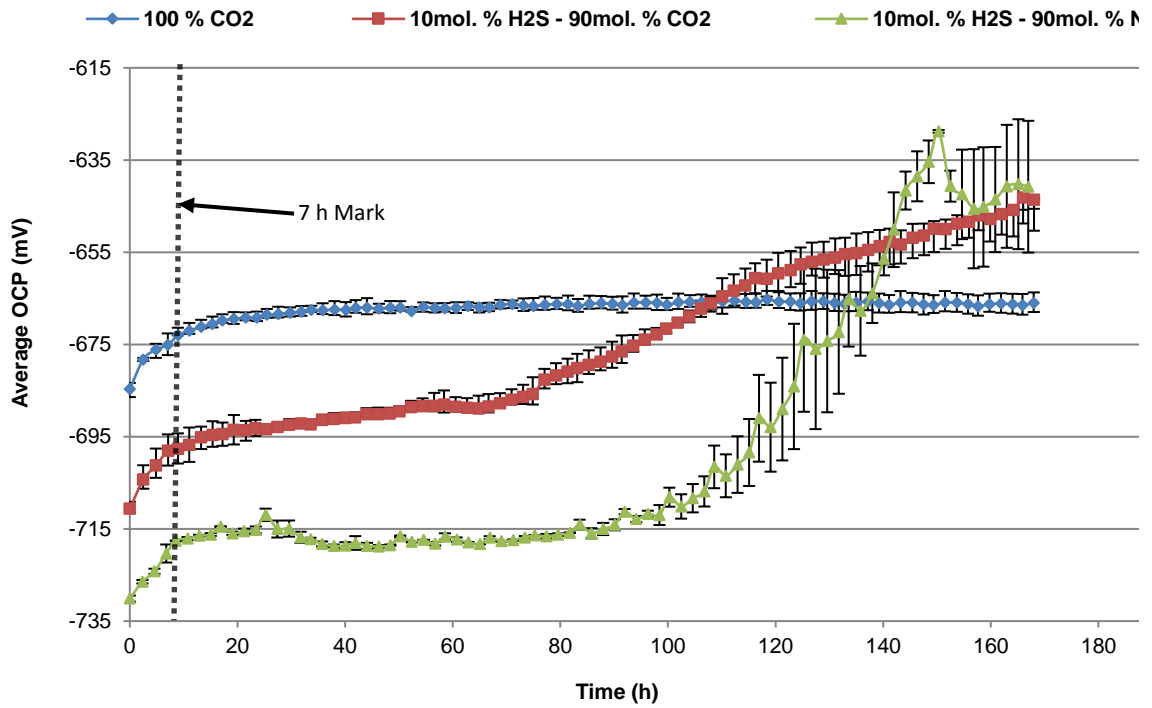
10  $\mu$ m

E

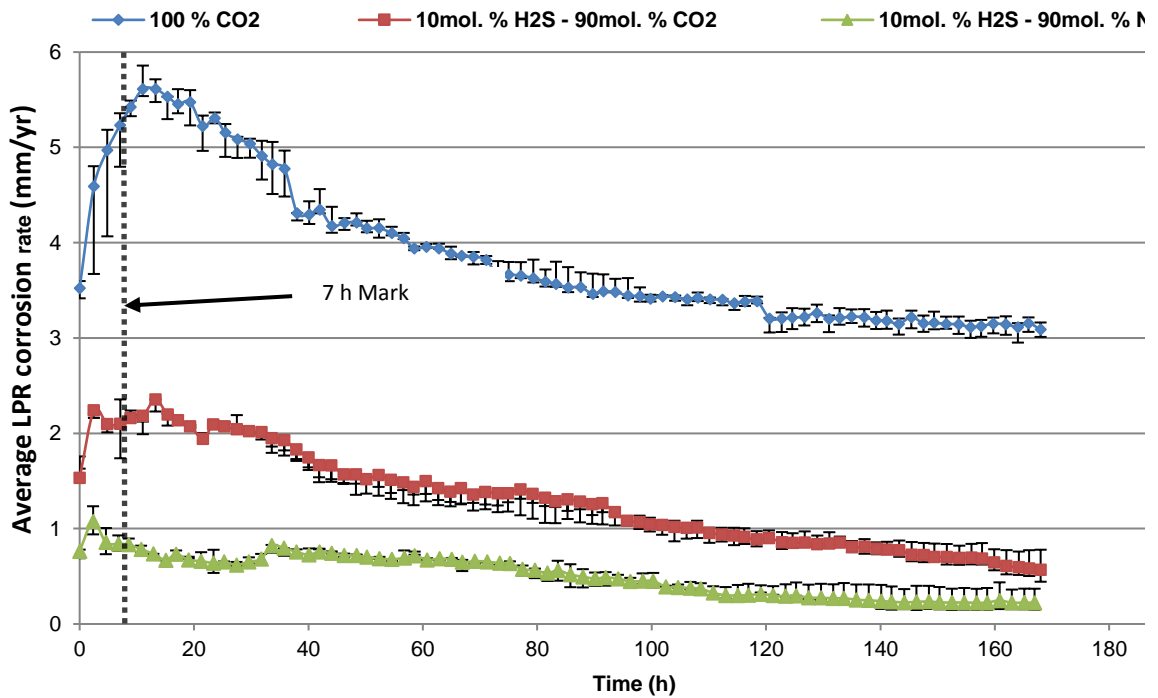


F

Figure 4: SEM images and XRD patterns of corrosion product layer on X65 carbon steel in 3.5 wt.% NaCl solution under gas atmospheres composed of (a) 100 mol.% CO<sub>2</sub>, (b) XRD pattern for 100 mol.% CO<sub>2</sub> (c) 10 mol.% H<sub>2</sub>S- 90 mol.%CO<sub>2</sub> (d) XRD pattern for 10 mol.% H<sub>2</sub>S- 90 mol.%CO<sub>2</sub> (e) 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> and (f) 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at 30°C and after 168 h.

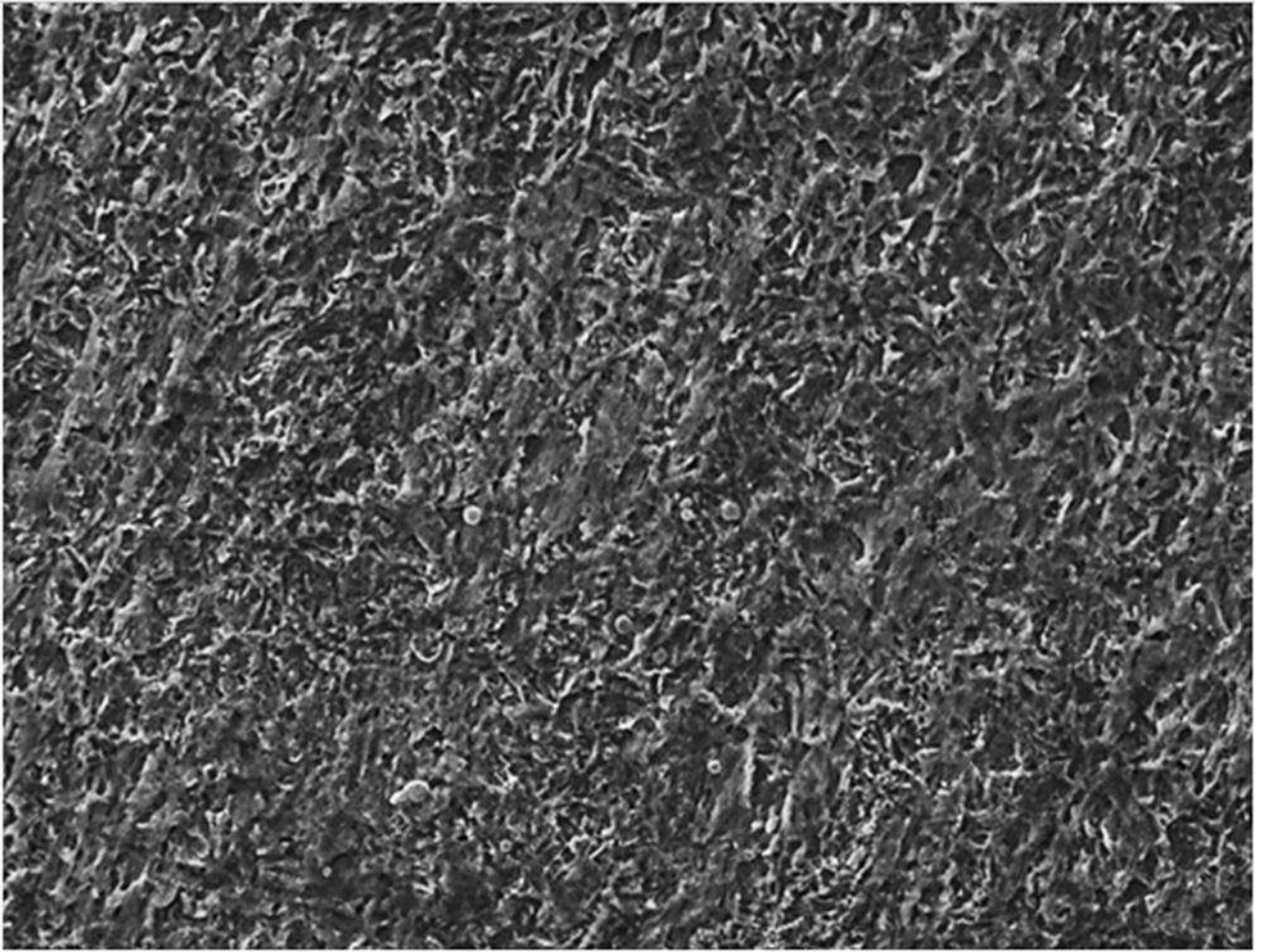


**A**



**B**

Figure 5: Graphs of (a) corrosion potential and (b) corrosion rate of X65 carbon steel in 3.5 wt. % NaCl solution under three different gas atmospheres at 80°C, over 168 h.



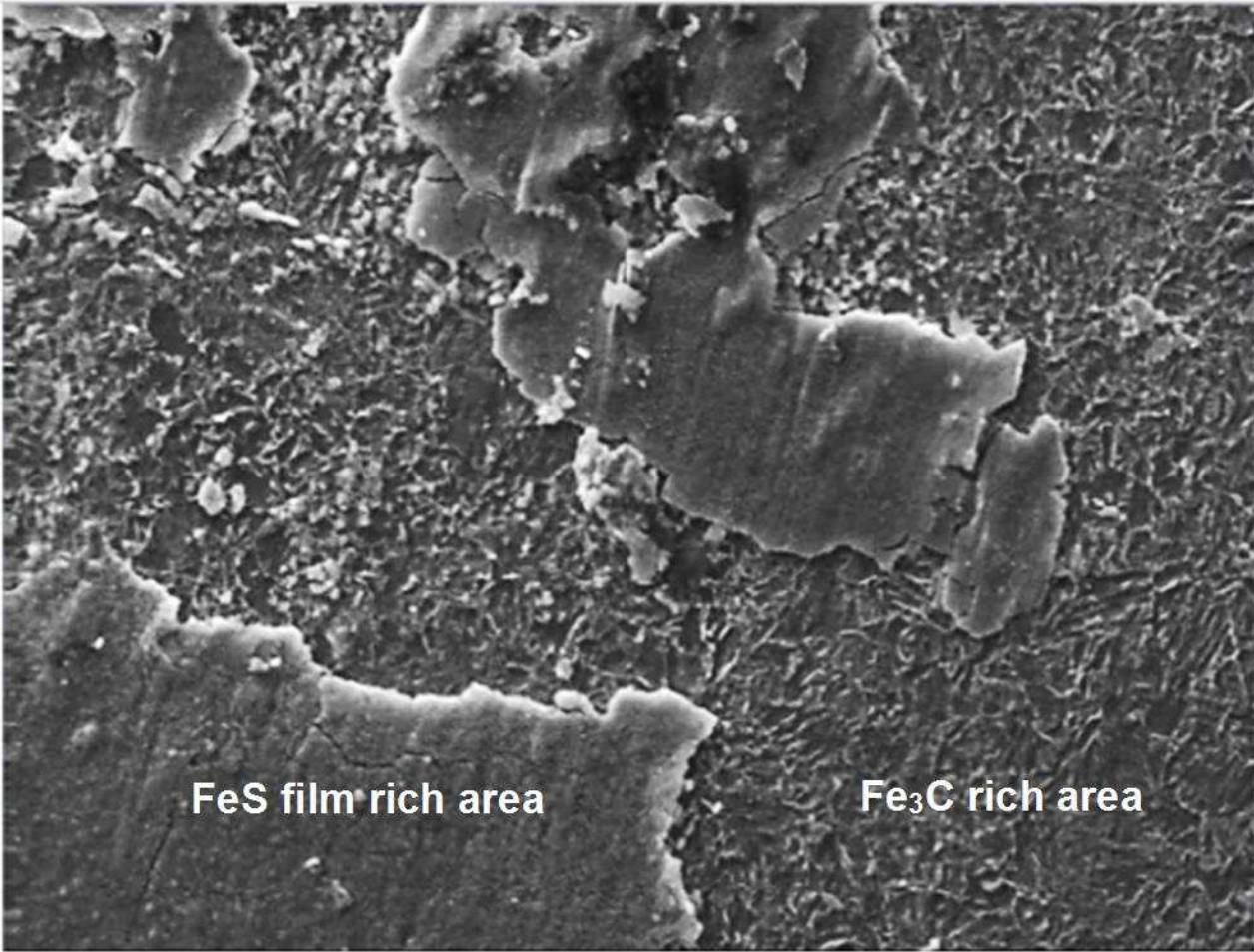
Mag = 3.00 KX

20.00 kV

SE1

10  $\mu$ m

A



Mag = 3.00 KX

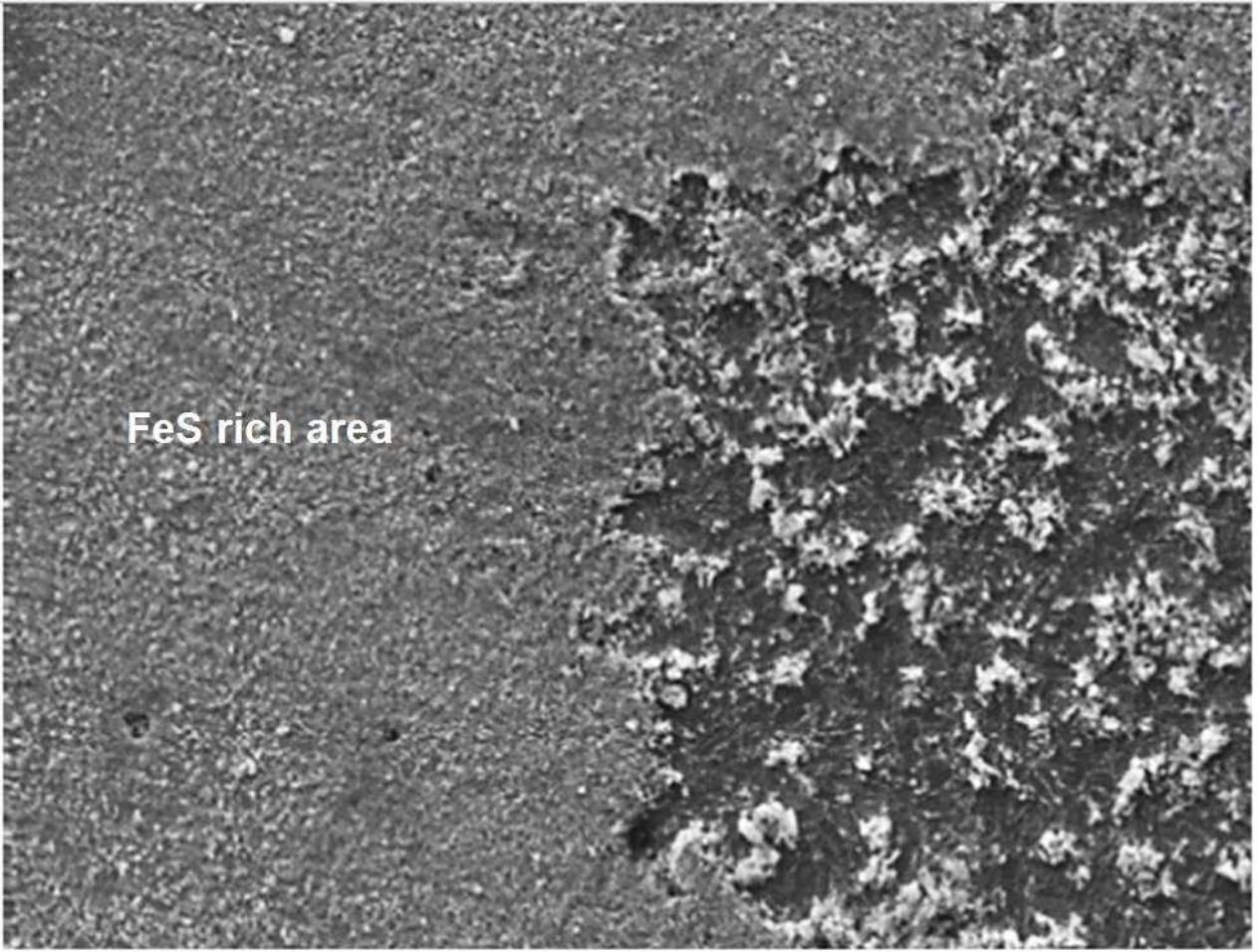
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SE1

10  $\mu$ m

6B





FeS rich area

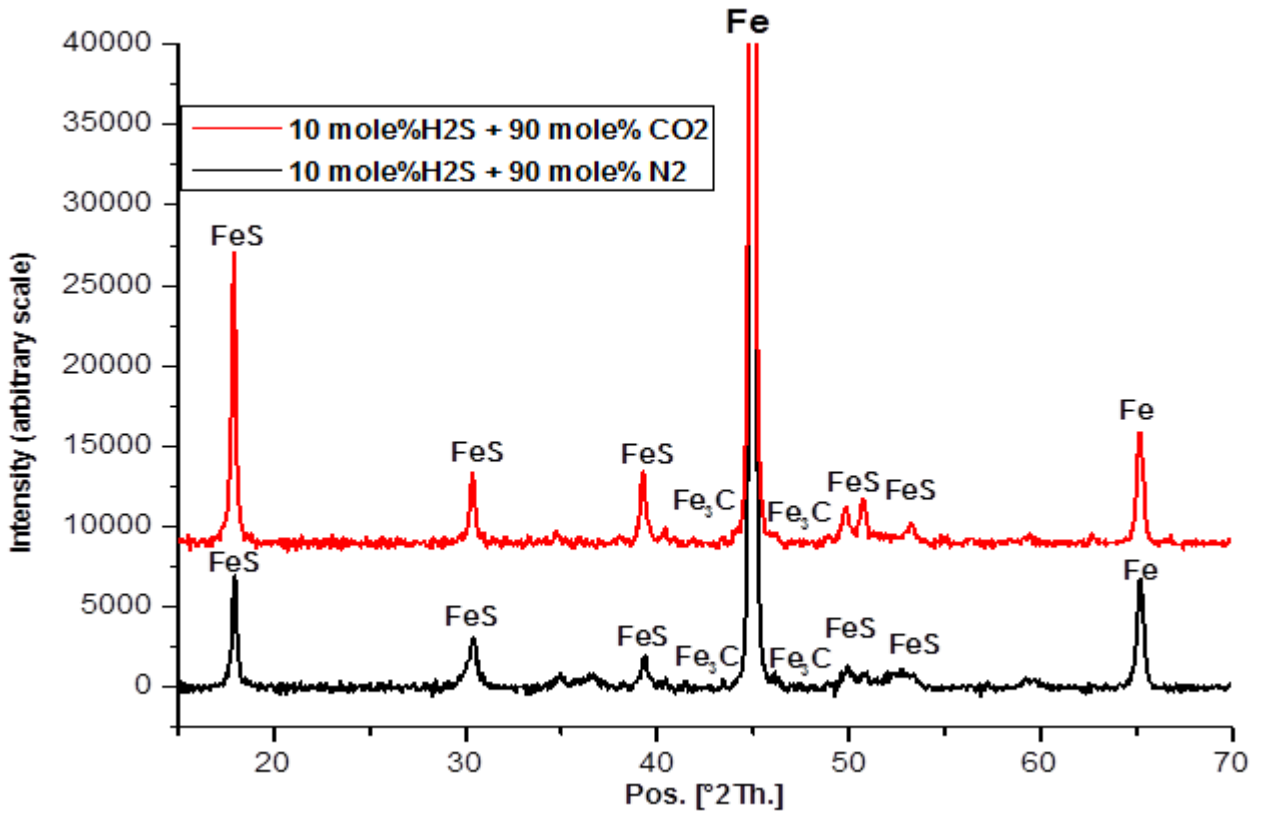
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SE1

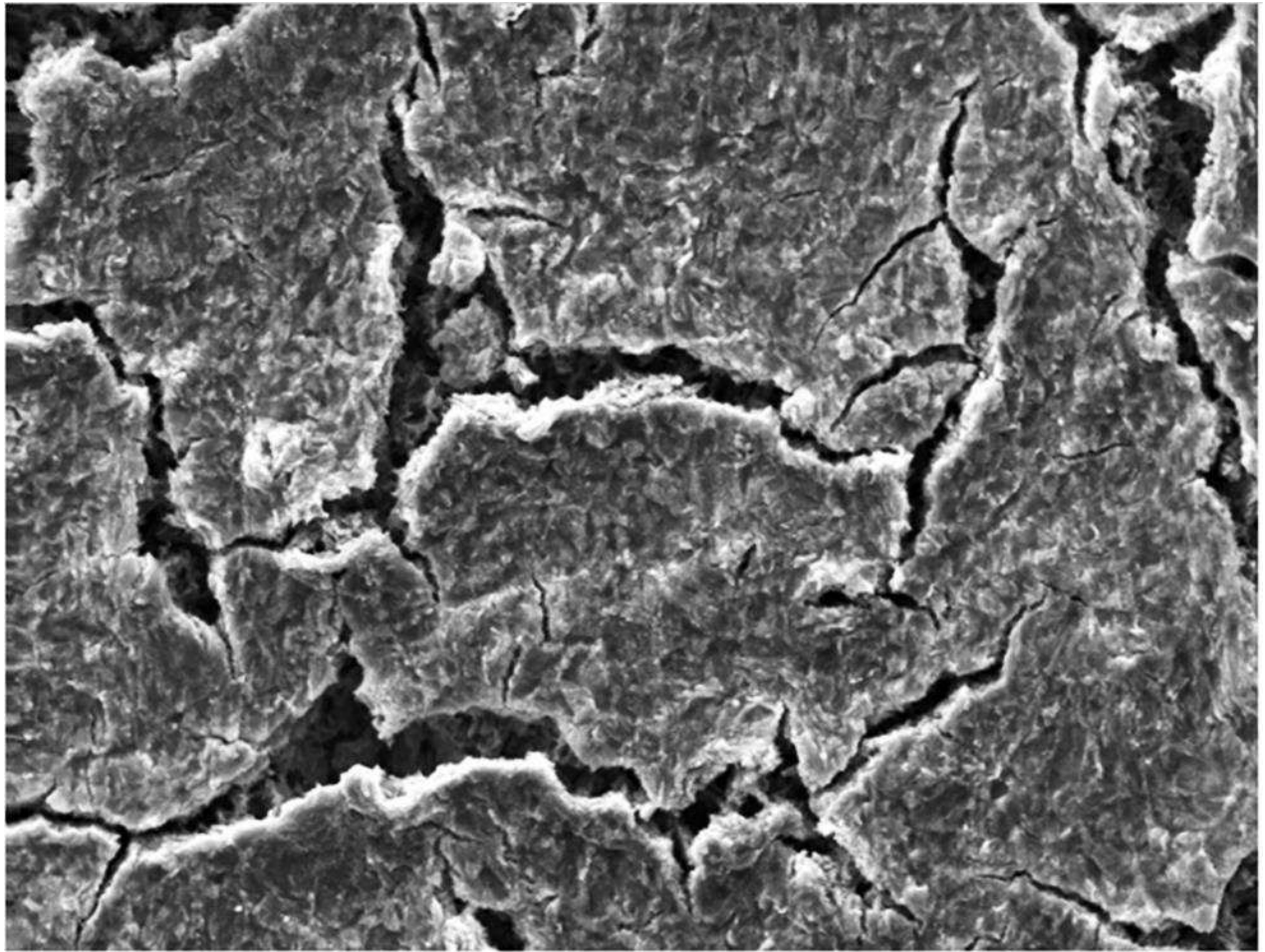
10  $\mu$ m

C



**D**

Figure 6: SEM images of corrosion product layer on X65 carbon steel in 3.5 wt.% NaCl solution saturated with (a) 100 mol.% CO<sub>2</sub>, (b) 10 mol.% H<sub>2</sub>S- 90 mol.% CO<sub>2</sub> and (c) 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at 80°C. (d) XRD pattern for corrosion product layer on X65 carbon steel in 3.5 wt.% NaCl solution saturated 10 mol.% H<sub>2</sub>S- 90 mol.% CO<sub>2</sub> and 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at 80°C for test after 7 h. (The intensity scale is arbitrary).



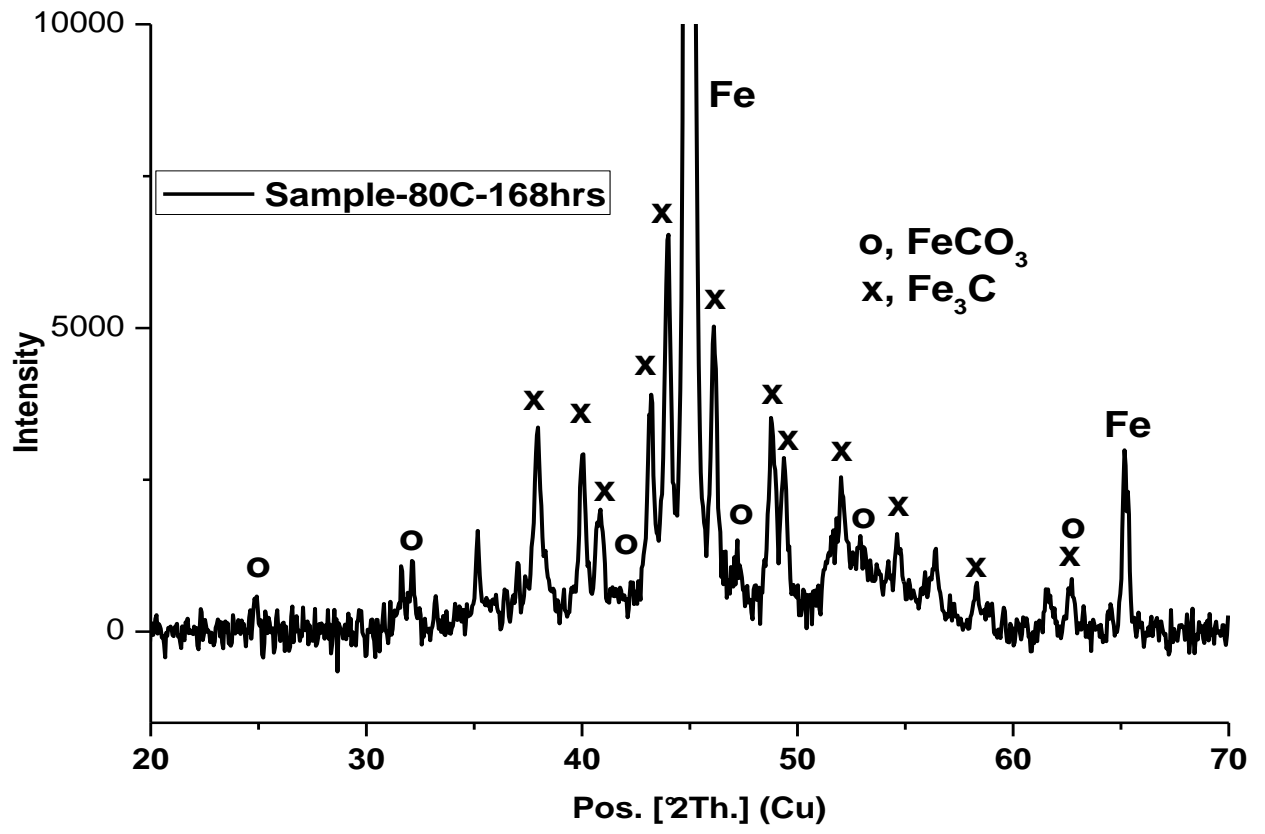
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20.00 kV

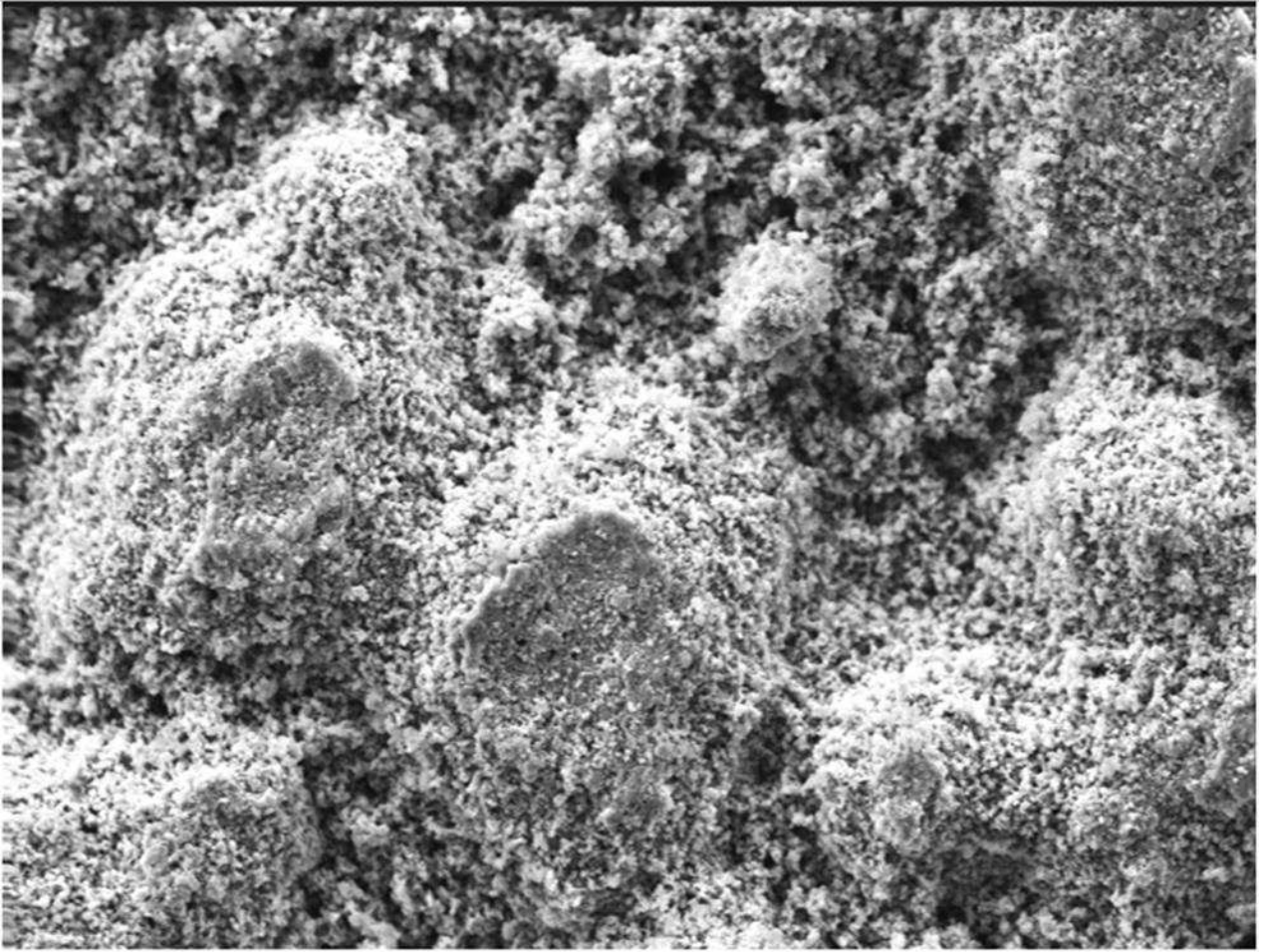
SE1

10  $\mu$ m

A



B



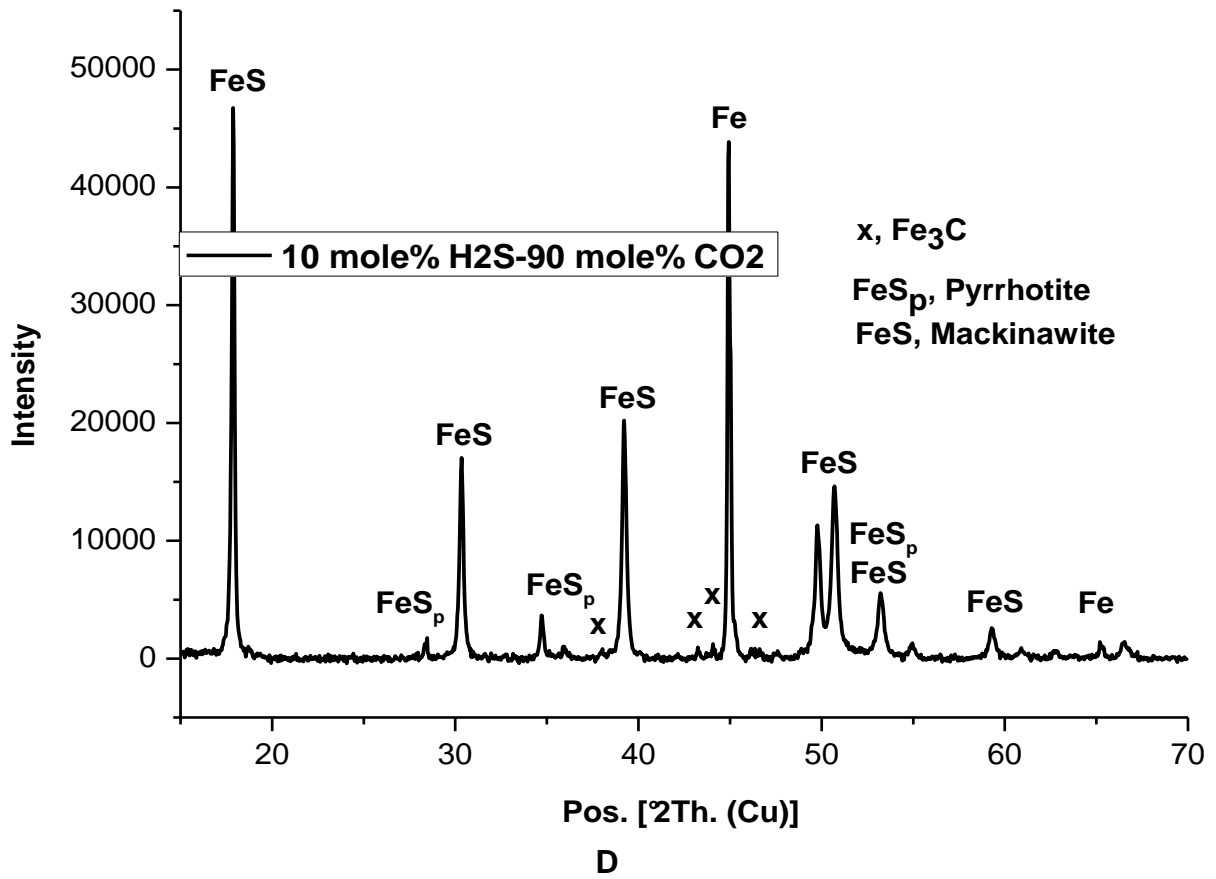
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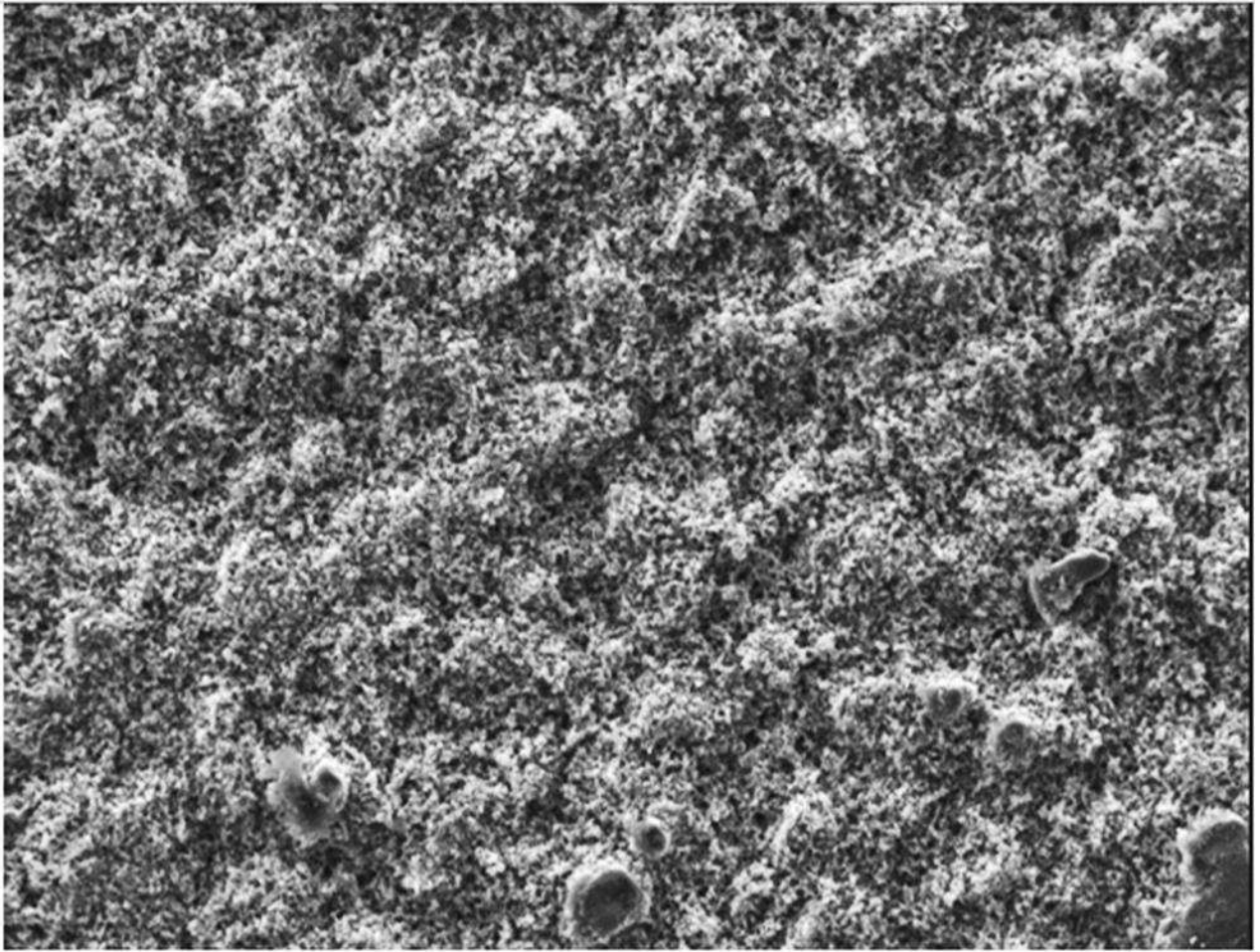
20.00 kV

SE1

10  $\mu$ m

C





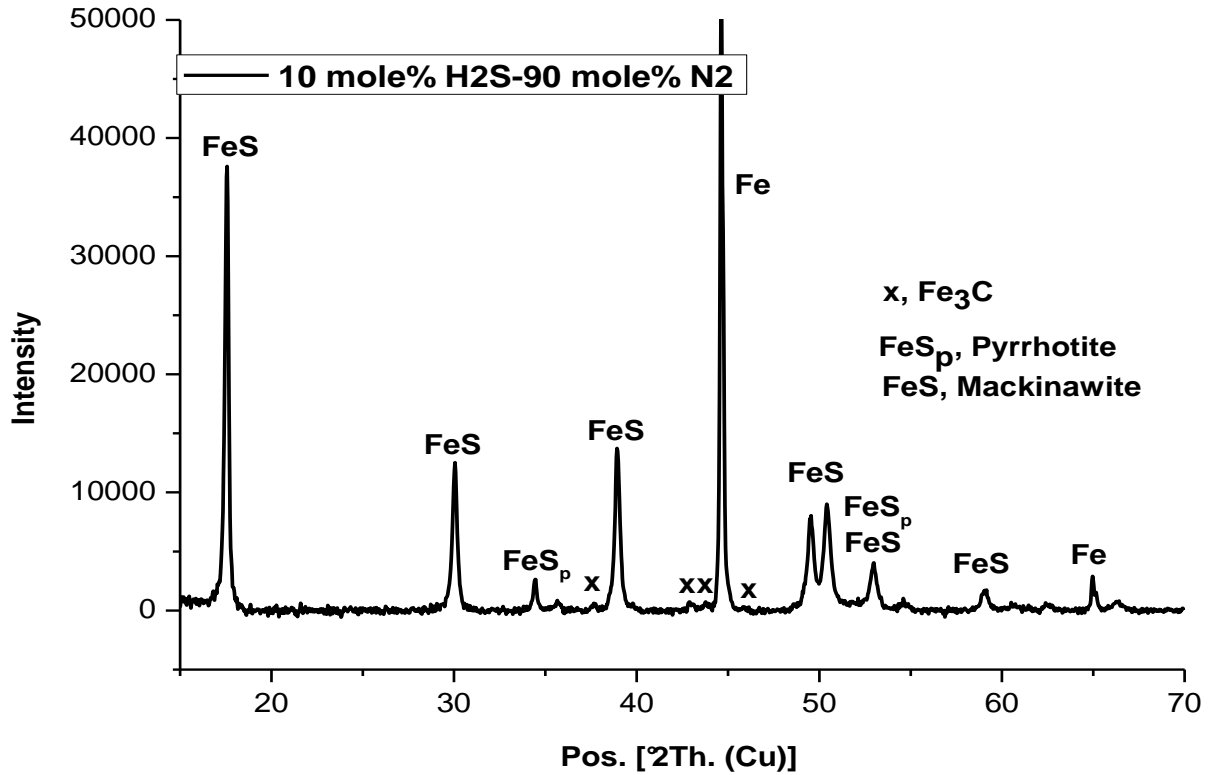
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20.00 kV

SE1

10  $\mu$ m

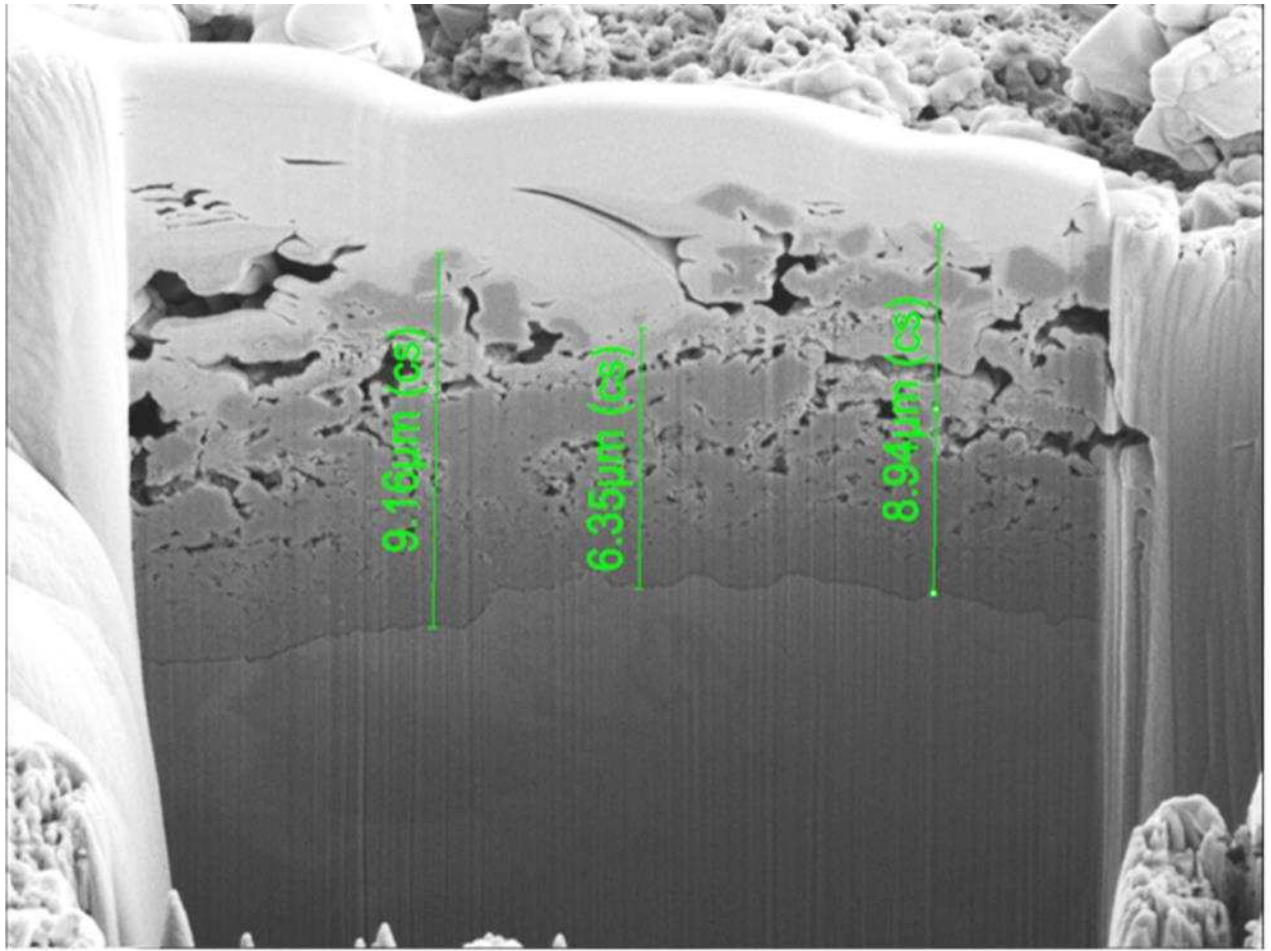
E



F

Figure 7: SEM images and XRD patterns of corrosion product layer on X65 carbon steel in 3.5 wt.% NaCl solution under gas atmospheres composed of (a) 100 mol.% CO<sub>2</sub>, (b) XRD pattern for 100 mol.% CO<sub>2</sub> (c) 10 mol.% H<sub>2</sub>S- 90 mol.%CO<sub>2</sub> (d) XRD pattern for 10 mol.% H<sub>2</sub>S- 90 mol.% CO<sub>2</sub> (e) 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> and (f) 10 mol.% H<sub>2</sub>S-90 mol.% N<sub>2</sub> at 80°C and after 168 h.





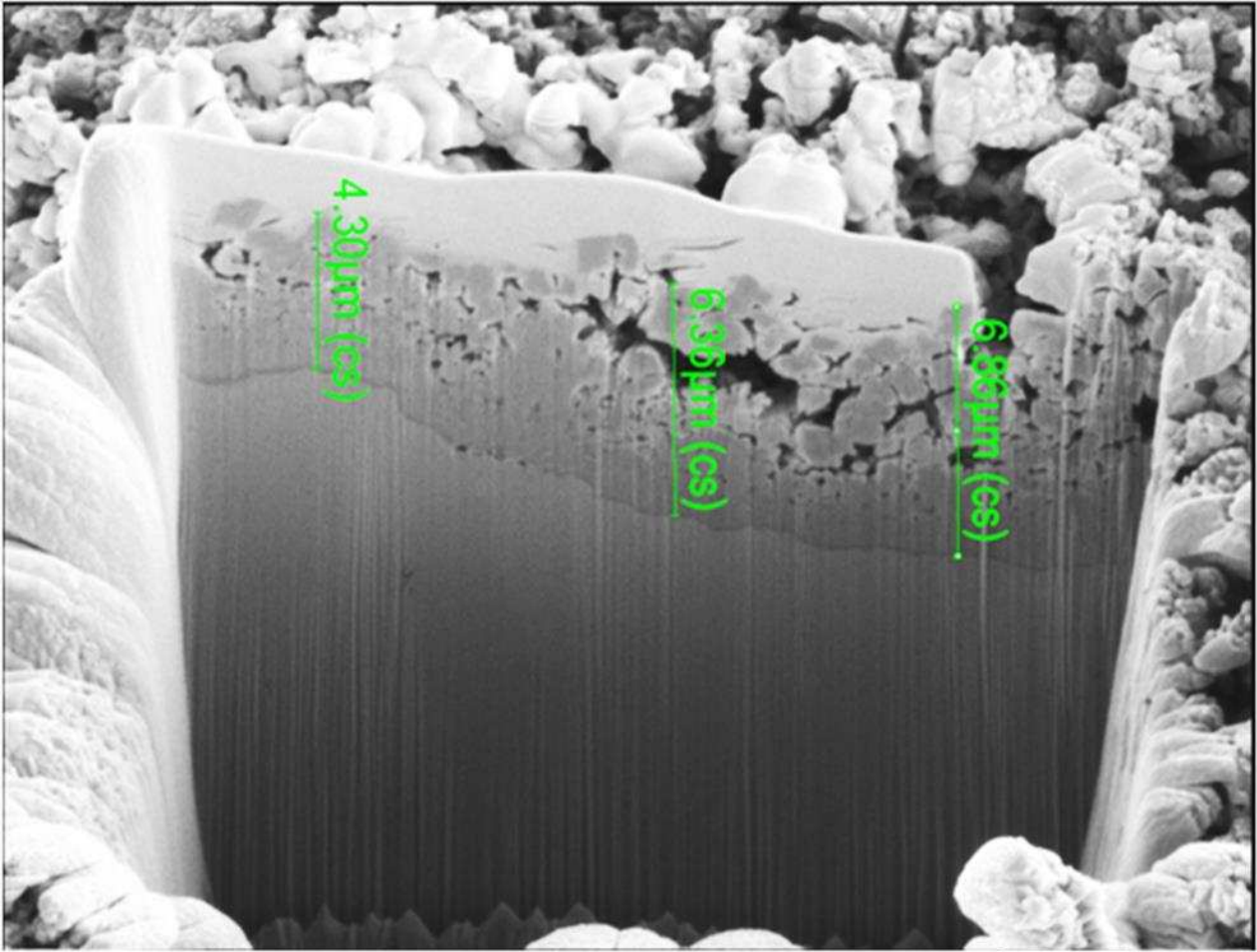
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5.00 kV

SE1

5 μm

A



Mag = 12.00 KX

5.00 kV

SE1

5 μm

**B**

Figure 8: Cross-sectional view after micro-machining using the FIB for (a) SEM image shown in Figure 13(c) for 10 mol.% H<sub>2</sub>S- 90 mol.% CO<sub>2</sub> and (b) SEM image shown in Figure 13(e) for 10 mol.% H<sub>2</sub>S- 90 mol.% N<sub>2</sub> at 80°C

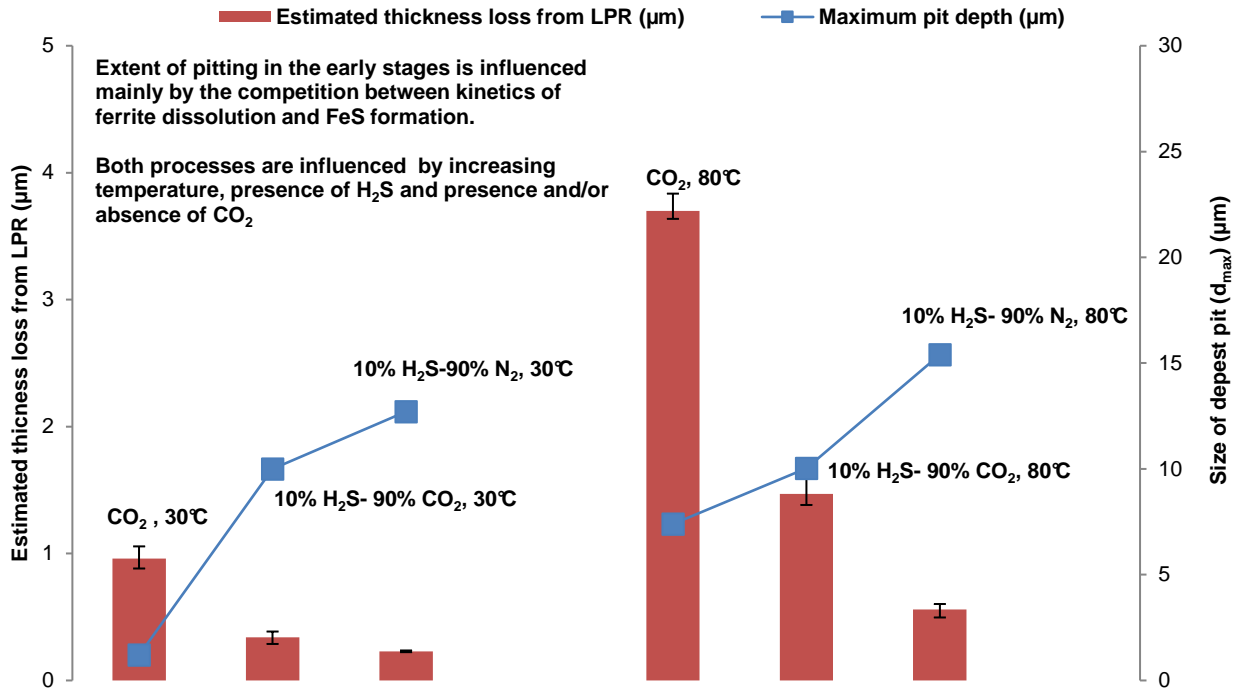
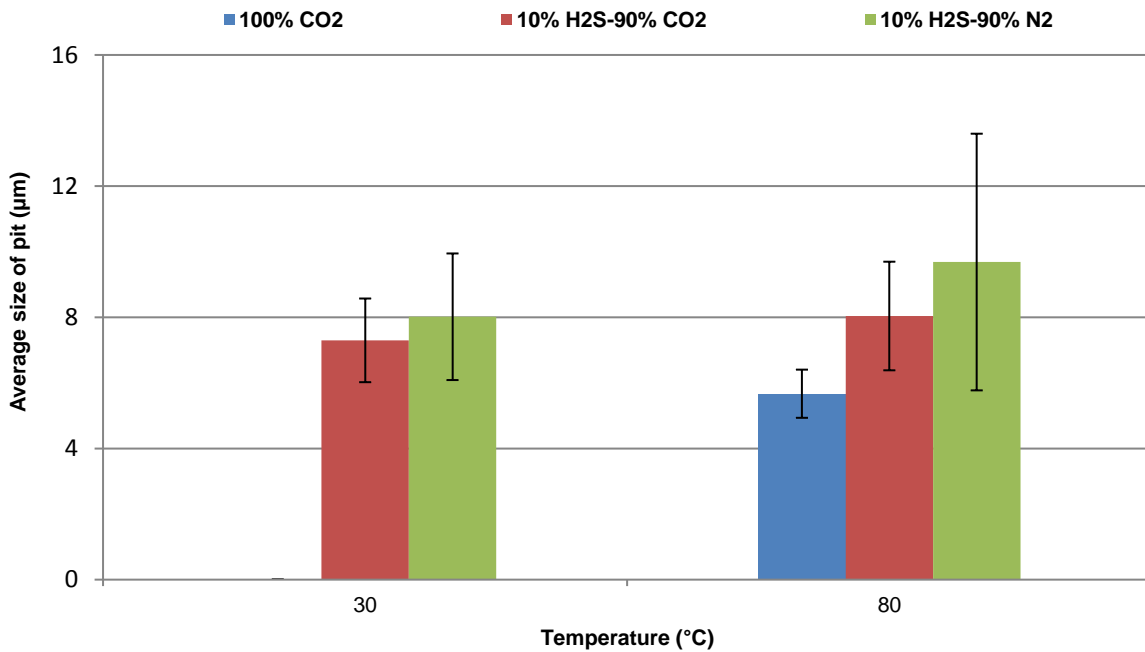
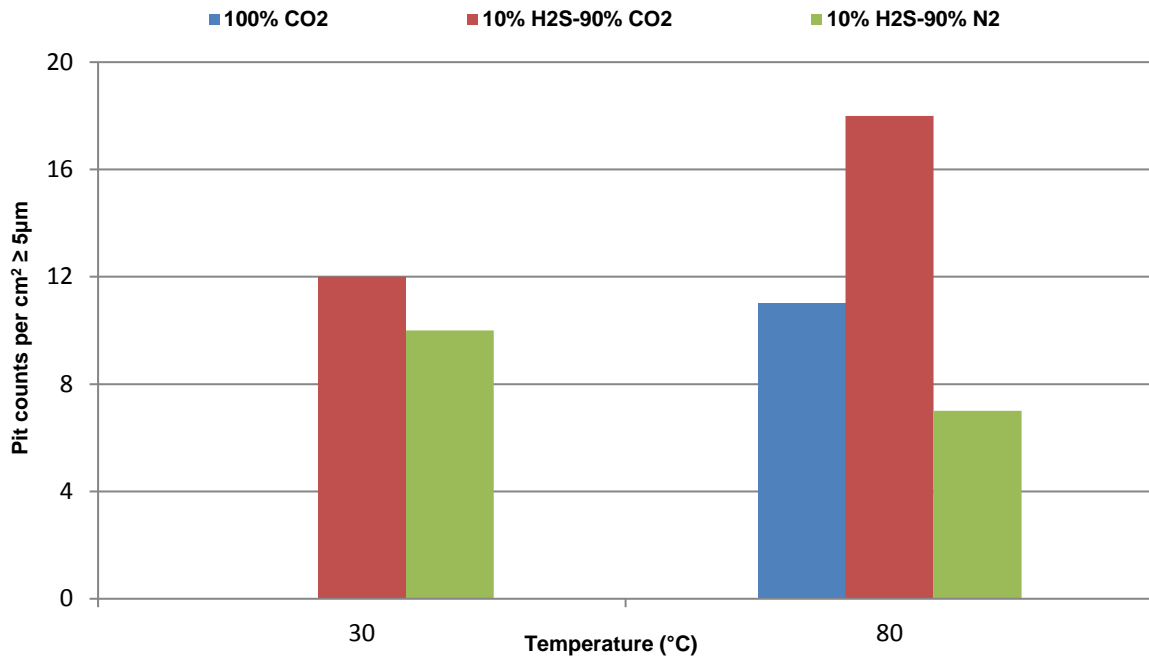


Figure 9: Summary of relationship between estimated thickness loss due to uniform corrosion and size of deepest initiated pit (relative to corroded surface) as a function of environmental parameters in  $\text{H}_2\text{S}$ -containing corrosion systems after 7 h.

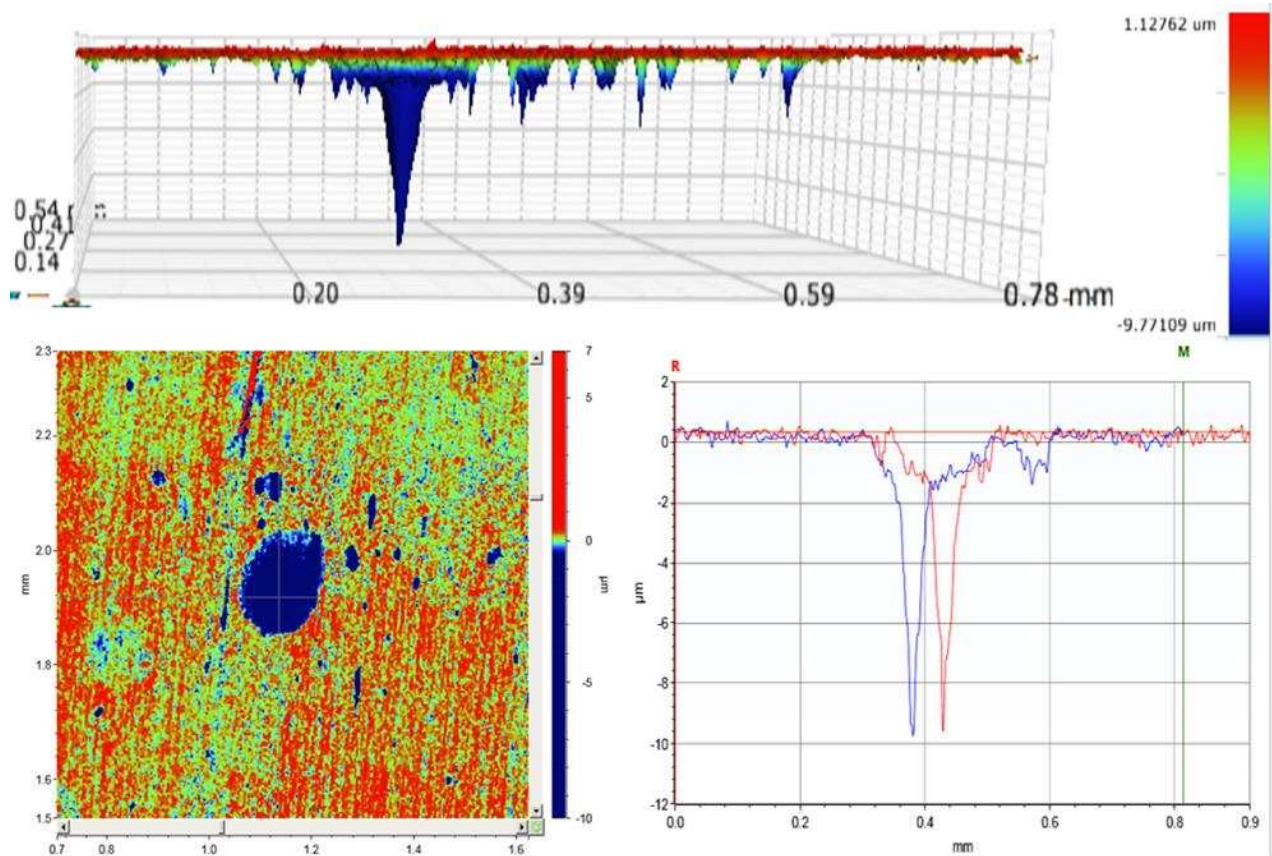


A

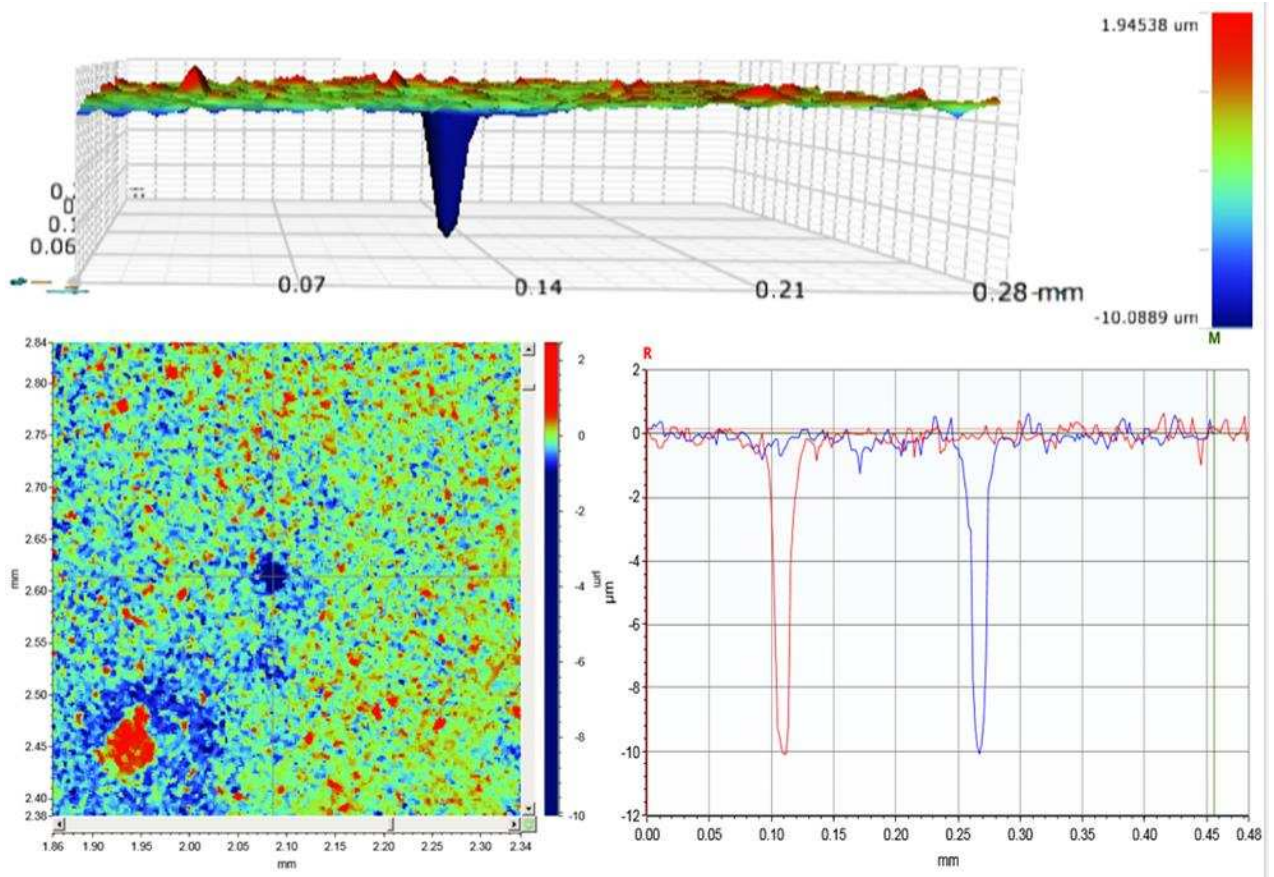


**B**

Figure 10: (a) Average pit depth (relative to corroded surface) and (b) Number of pits  $\geq 5\mu\text{m}$  per  $1\text{ cm}^2$  area of carbon steel surface exposed to corrosion system under 100 mol. %  $\text{CO}_2$ , 10 mol. %  $\text{H}_2\text{S} - 90\text{ mol. \% CO}_2$  and 10 mol. %  $\text{H}_2\text{S} - 90\text{ mol. \% N}_2$  gas atmosphere as a function of temperature after 7 h. (Error bars are based on the standard deviation from the average of size of 10 deepest pit)



**A**



**B**

Figure 11: 2D and 3D images of deepest pits (relative to corroded surface) on carbon steel surface exposed to corrosion system under 10mol.% H<sub>2</sub>S – 90 mol.% CO<sub>2</sub> for 7 h at (a) 30°C and (b) 80° C.

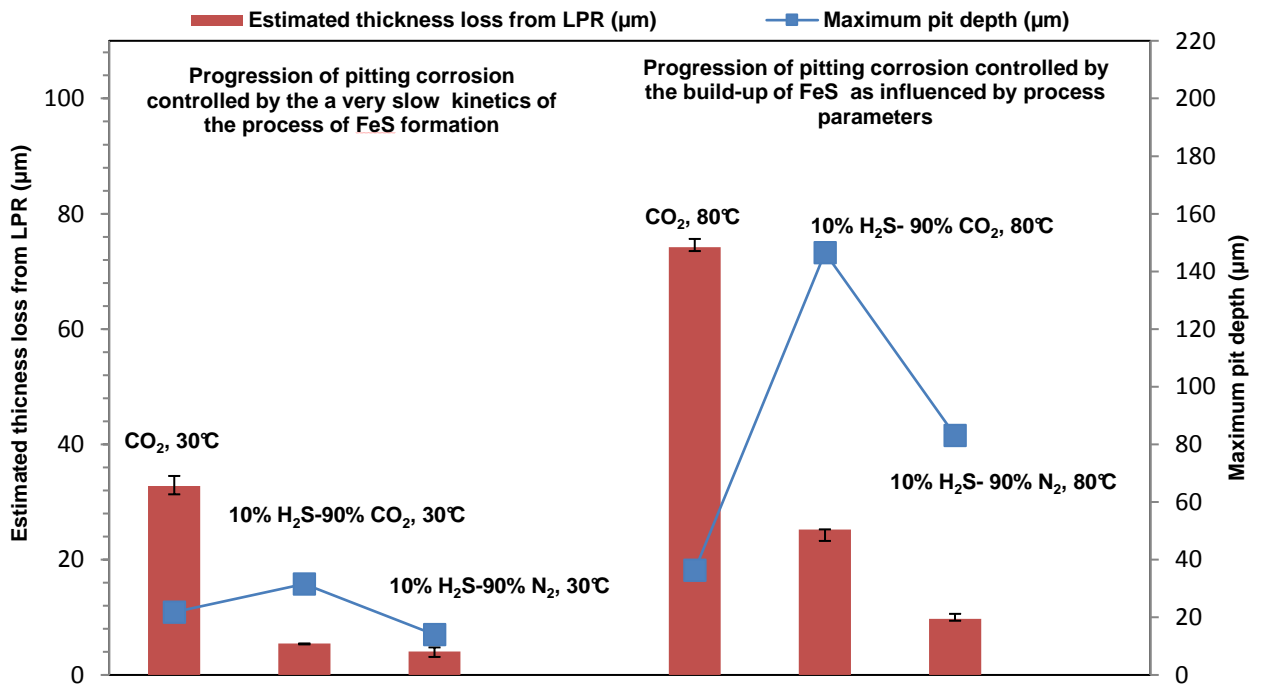


Figure 12: Summary of relationship between estimated thickness loss due to uniform corrosion and size of deepest propagated pit (relative to corroded surface) as a function of environmental parameters in H<sub>2</sub>S-containing corrosion systems after 168 h

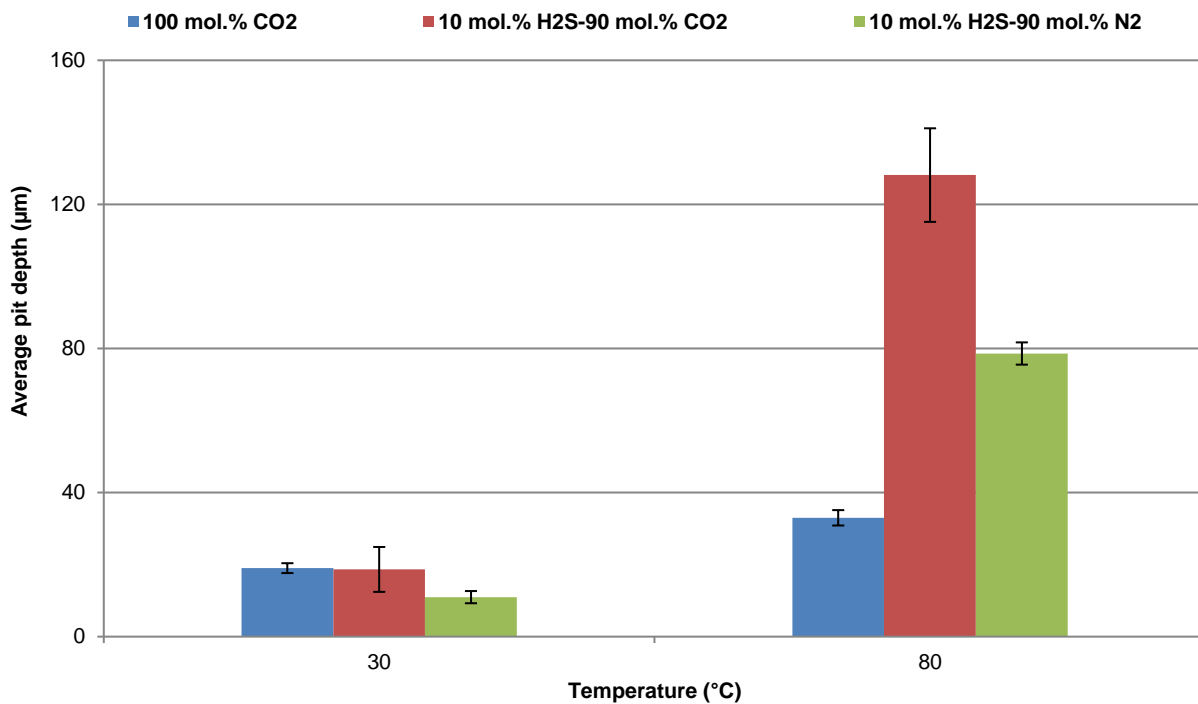


Figure 13: Average pit depth (relative to corroded surface) on carbon steel surface exposed to corrosion system under 100mol.% CO<sub>2</sub>, 10mol.% H<sub>2</sub>S - 90mol.% CO<sub>2</sub> and 10mol.% H<sub>2</sub>S - 90mol.% N<sub>2</sub> gas atmosphere for 168 h as a function of temperature. (Error bars are based on the standard deviation from the average of size of 10 deepest pit)

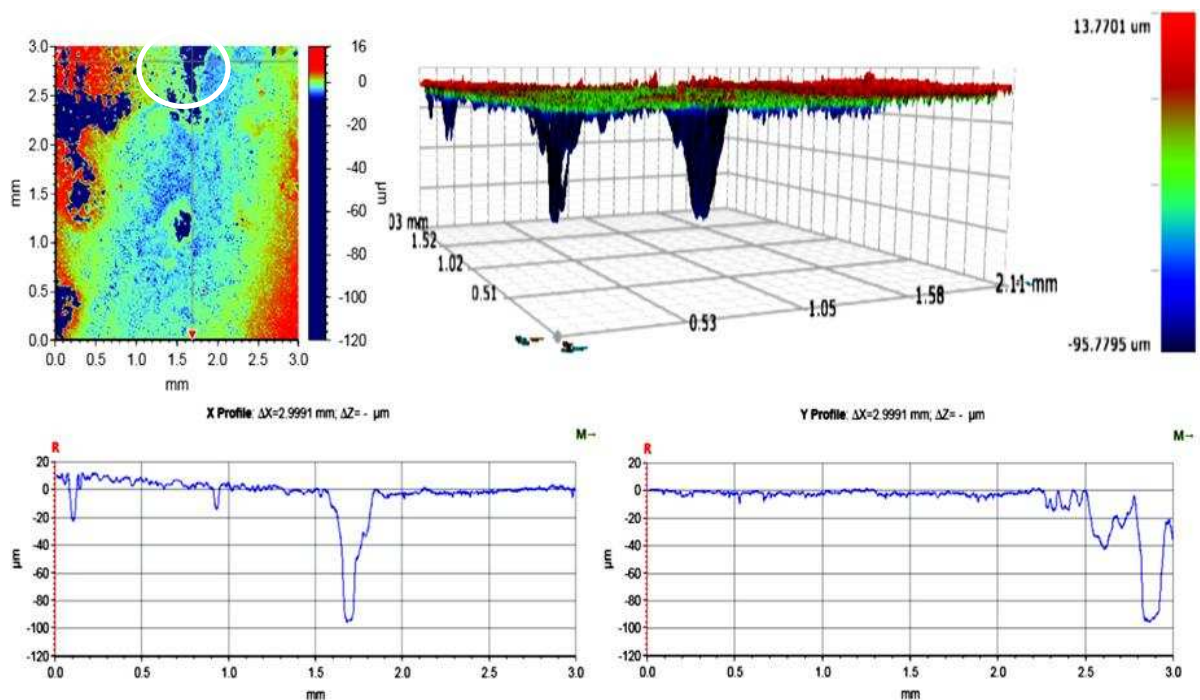


Figure 14: 2D and 3D images of deepest pit (relative to corroded surface) on carbon steel surface exposed to corrosion system under 10mole% H<sub>2</sub>S - 90mole% CO<sub>2</sub> after 168 h at 80°C, after 168 h.