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# The Impact of Shrinkage Reducing Admixtures on the Corrosion of Steel Rebar in Concrete

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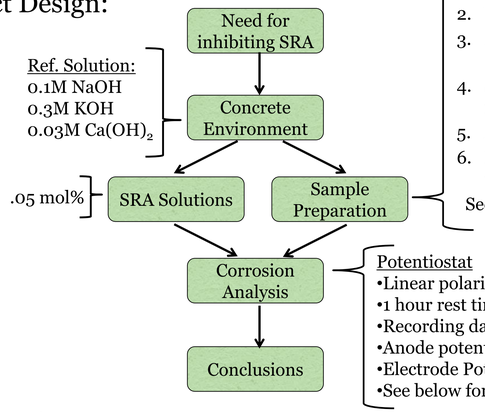
## Abstract:

Chemical admixtures are prepared in modern concrete to control certain performance properties, such as strength, setting-time, and workability. In this research, the corrosion inhibition properties of various shrinkage reducing admixtures in a synthetic concrete pore solution are examined. These compounds can inhibit or promote corrosion of the carbon steel rebar in concrete structures. The corrosive effects were tested by modeling the environment of concrete in a cathodic cell with a similar pH (12-13). Each shrinkage-reducing admixture (SRA) was compared to a standard reference cell. Tafel curves were used to determine the corrosion current and potential.

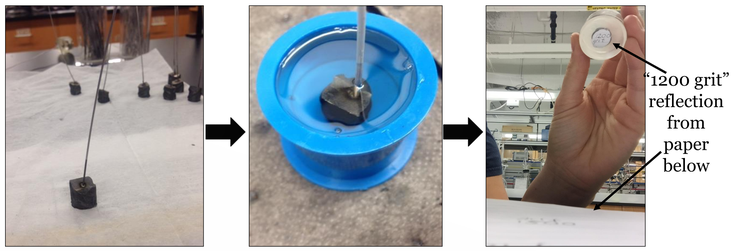
## Introduction:

- Corrosion of carbon steel (CS) rebars in concrete is becoming a more frequent issue with no general solution.
- Consequences of corrosion are apparent with increasing number of concrete structures in corrosive environments (seawater and salty road run-off).
- The demand for an SRA with inhibiting corrosive properties is extremely high.
- The four SRAs analyzed in this research are:
  1. Diethylene glycol
  2. Dipropylene glycol
  3. Glycerol
  4. Analog Compound

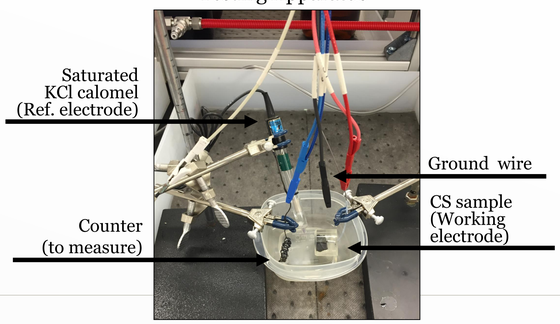
## Project Design:




Step #2 Step #4 Step #6

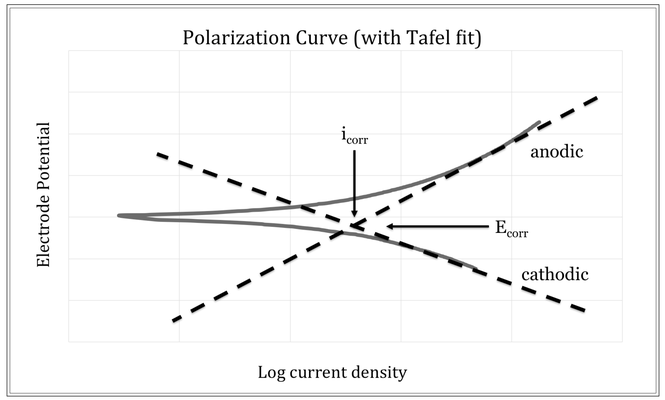


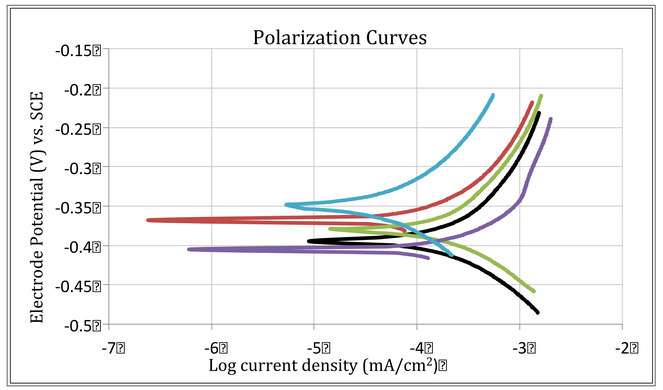

Testing Apparatus

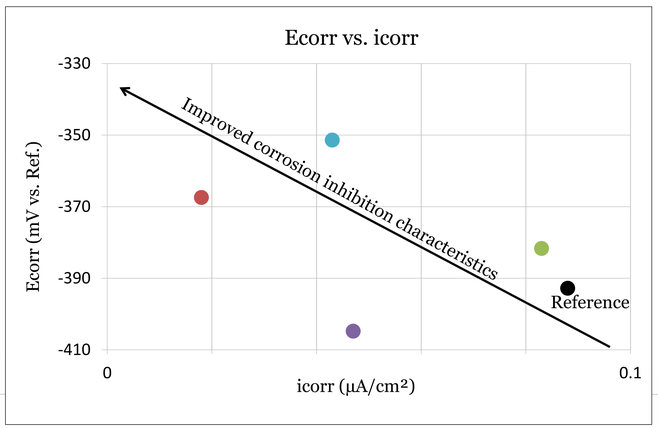



## Results:

● Reference ● Diethylene Glycol ● Dipropylene Glycol ● Glycerol ● Analog Compound




| Solution | icorr (µA/cm²) | Ecorr (mV vs. Ref.) | pH | Conductivity (mS/cm) | Corrosion rate (µm/yr) |
|---|---|---|---|---|---|
| Reference | 0.088 | -392.8 | 12.15 | 81.76 | 1.02 |
| Diethylene Glycol (1) | 0.018 | -367.4 | 12.84 | 54.66 | 0.209 |
| Dipropylene Glycol (2) | 0.083 | -381.7 | 13.03 | 67.37 | 0.963 |
| Glycerol (3) | 0.047 | -404.8 | 13.09 | 80.69 | 0.545 |
| Analog Compound (4) | 0.043 | -351.4 | 12.83 | 57.24 | 0.499 |

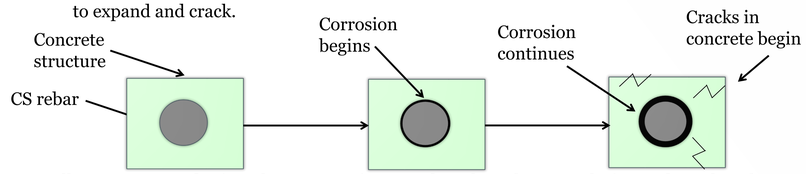
Corrosion rate was calculated as follows:

$$r = \frac{(3.27x10^{-6})i_{corr}(E.W)}{\rho}$$

r= corrosion rate (µm/yr)
$i_{corr}$= corrosion current (µA/cm²)
E.W.= equivalent weight (27.92g)
ρ= density (7.87g/cm³)

## Conclusion:

- Corrosion current, $i_{corr}$, is related to rate of corrosion
  - As $i_{corr}$ increases, the rate of corrosion increases (GOAL: low $i_{corr}$)
- Corrosion potential, $E_{corr}$, is a value to describe how readily a material wants to corrode
  - As $E_{corr}$ increases, the spontaneous corrosion decreases (GOAL: high $E_{corr}$)
- Nearly vertical ending polarization curves, shown to the left, indicate a limiting current
  - A limiting current indicates the anodic reaction is happening as quickly as possible allowing for horizontal shifts in the polarization curves with a constant current. (i.e. can change potential with other environmental changes)
  - As the limiting current increases, $i_{corr}$ increases (GOAL: low limiting current)
- Corrosion rate describes the penetration depth on the surface of the rebar
  - The surface reaction in the confined concrete structure causes the outer concrete surface to expand and crack.




- All SRA compounds give a lower corrosion rate than the reference solution and are therefore more corrosion inhibiting. In order of improving corrosion inhibiting properties:
  1. Diethylene glycol
  2. Analog compound
  3. Glycerol
  4. Dipropylene glycol
  5. Reference

## Continuing Research:

- Analyze affects of temperature dependence on polarization curves and how the corrosion potential shifts
- Test inhibition characteristics of SRAs in a small scale concrete sample.

## Acknowledgements:

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