Corrosion Reduction Using Two Coating Methods on Magnesium

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Motivation for Research
Automotive Industry:
- Corrosion of structural steel on vehicles
- Caused by salt-treated roads
- Focused on increasing gas mileage
- Two ways to increase gas mileage using current technology
- Improve efficiency of the engine
- Reduce the overall weight of the vehicle
- Engine cylinders, control arms, braking
- Change the structural material
- Needs to be lighter than steel
- Needs to be as stiff as steel
- Needs to be easy to shape
- Possible Replacement Metals
  - Aluminum, Magnesium
  - Metals prone to corrosion

Why Use Magnesium?
Magnesium Alloys:
- Desirable for use to replace heavy engine parts
- High-strength to weight ratio
  - Steel: 257 Gpa
  - Magnesium: 73 Gpa
- High strength to weight ratio
  - Steel: 107,000 MPa
  - Magnesium: 114,900 MPa
- Excellent Corrosion and Easy Machinability
- Easily corroded in the presence of salt-water

Magnesium Corrosion
- Two Oxidation - Reduction Reactions
  - Magnesium and water
    - Forms magnesium hydroxide precipitate and hydrogen gas
  - Magnesium chloride, sodium chloride, and water
  - Magnesium chloride, sodium hydroxide, and hydrogen gas
  - Unlike other metal corrosion reactions, oxygen not needed
- Corrosion Locations
  - Surface Effects
  - Total corrosion
  - Pinning Corrosion
  - Weld Effect
  - Hydrogen Diffusion

Magnesium Corrosion cont.
Galvanic Corrosion:
- Two metals in contact
- One metal can corrode preferentially to another metal
- Magnesium corrosion can be accelerated if in contact with other metals on vehicle

Magnesium Alloys:
- Addition of elements to the magnesium
  - More expensive
  - Magnesium Alloy AE44
    - 4% Aluminum, 4% Rare Earth Elements, 92% Magnesium

Coating Magnesium - PEI
Polyetherimide:
- Amber colored and Amorphous
- 10,000 psi tensile strength
- Glass transition temperature: 277°C
- Density: 1.27 g/cm³
- Hydrophobic and solvent resistant
- Repeatability of the material
- Not easily degradable by salt and other chemicals on the road
- Prevents direct contact with other metals
- Two Methods Tested
  - Polymer Solution Coating
  - Polymer Film

Solution Coating
- Preparing magnesium samples
  - Sandblasted with 100, 300, and 1200 grit sandpaper
  - Washed with Acetone, Anisole, Semiconductor, and Ethyl Alcohol
- Preparing polymer solution
  - 0.56% of PEI in 145.5 mL of DCN (N,N-dimethylacetamide)
- Dip samples in solution
  - Samples were hung via paper clips to dry off
  - After 24 hrs, solution solidifies and samples left with polymer coating

Procedure
Results: Uncoated Magnesium
- Untreated AE44 Magnesium
  - Corrosion is stable within 10 seconds
  - Significant corrosion after 24 hours

Different Coating Layers
- 10 layers
  - Small amount of corrosion appeared at 5 minutes
  - Stream of bubbles began at 30 minutes
- 20 layers
  - Small amount of corrosion appeared at 5 minutes
  - Stream of bubbles began at 40 minutes
- 30 layers
  - Small amount of corrosion appeared at 30 minutes
  - Stream of bubbles began at 40 minutes
- 40 layers
  - Small amount of corrosion appeared at 40 minutes
  - Stream of bubbles began at 50 minutes

Film - Wrapped Magnesium
- One layer of film
  - No signs of corrosion occurred within 1 hour
  - Small amounts of corrosion began to occur on one side near the hole at 2 hours
  - At 24 hours, corrosion continued on one side, but not the other
- Two layers of film
  - No signs of corrosion occurred within 24 hours
  - Minimal corrosion at 72 hours

Comparison of Methods

Conclusions and Future Work
Polyetherimide increased time to corrosion
- Thicker the coating, longer to initial corrosion bubble formation, and destructive corrosion
- Polymer film vs peptil
  - Reduces corrosion
  - Compares more data on differences in layers
- Developing a chemical bond between alloy and polymer
  - Stronger adhesion