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Materials Susceptibility in Contaminated Alternative Fuel

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Wendy J. Goodson, PhD

**Principal Investigator/Technical Lead
Materials and Manufacturing Directorate**

Wright-Patterson AFB, OH 45433

wendy.goodson@wpafb.af.mil



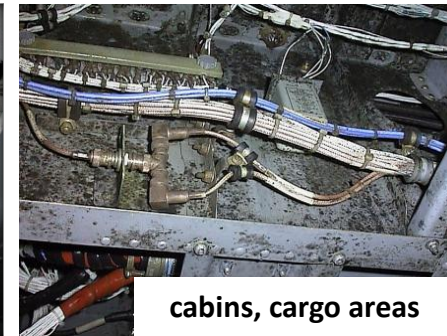
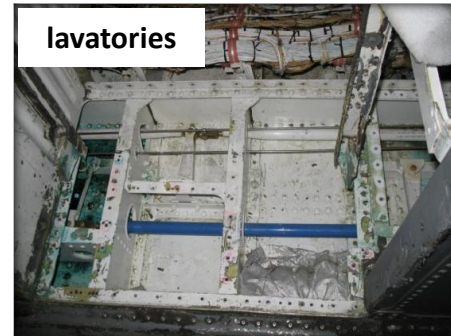


Biocorrosion* in the AF?

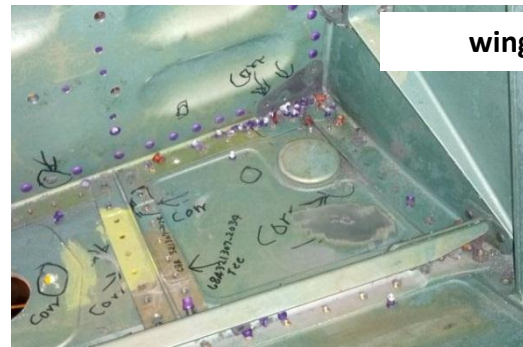


*DoD definition of corrosion = deterioration of metallics and non-metallics

Systems exposed to extended moisture, standing water, biological fluids



Fuel systems and infrastructure

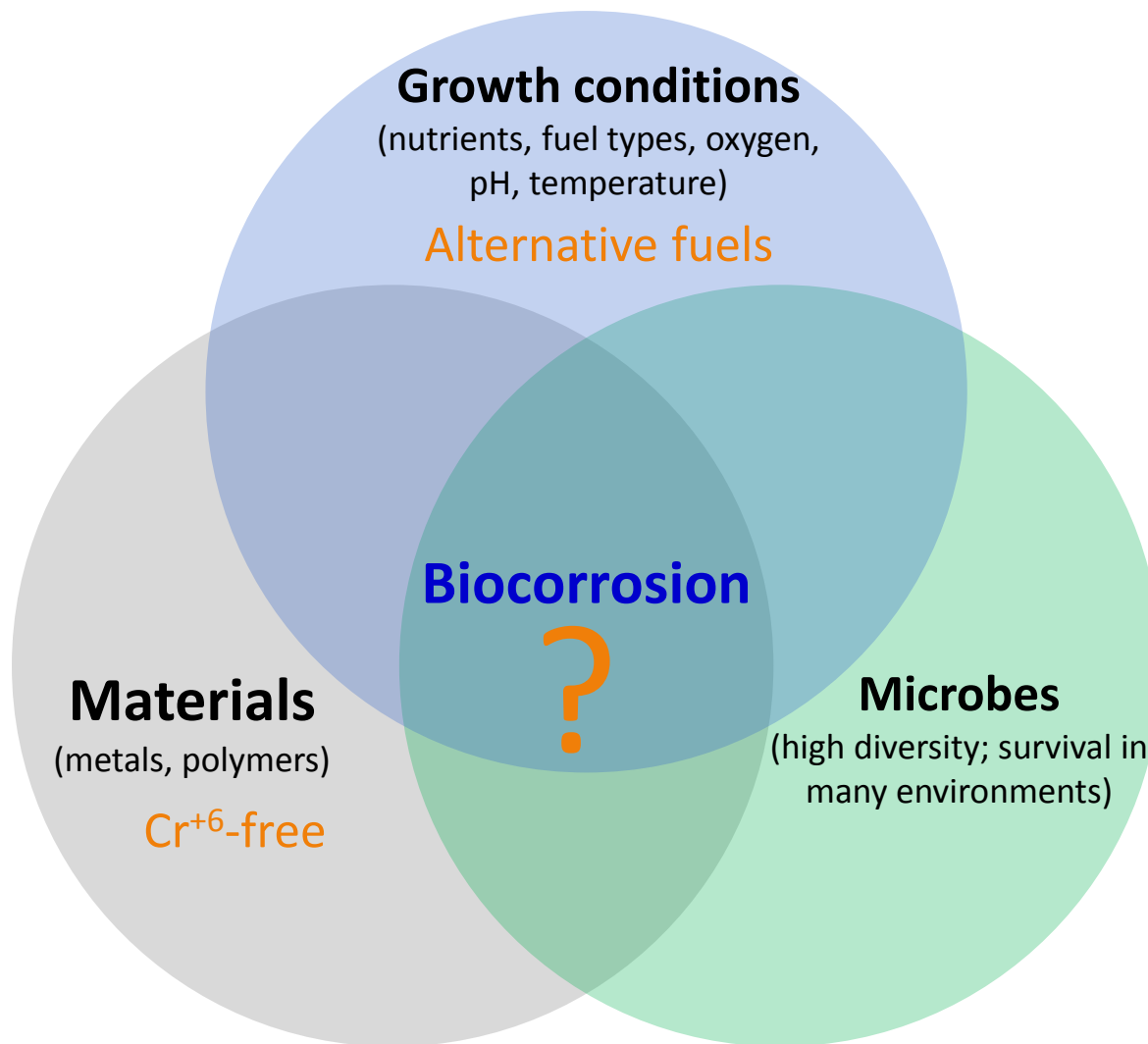


What is the **frequency** of biocorrosion in the AF?

How do **rates of (aerobic) biocorrosion** compare to other types of corrosion?

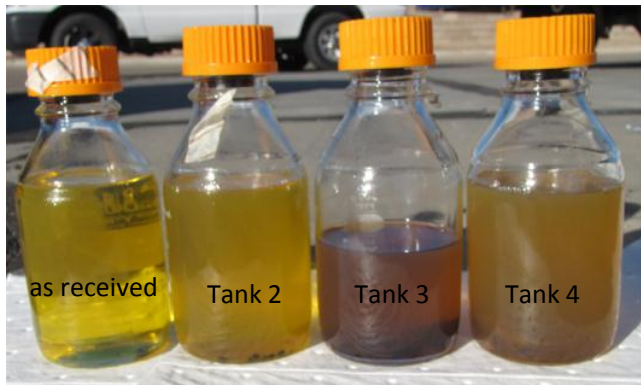


Factors Contributing to Biocorrosion



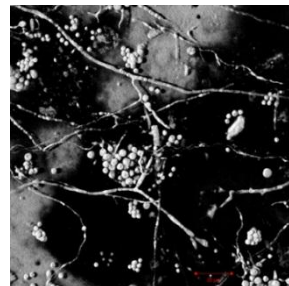
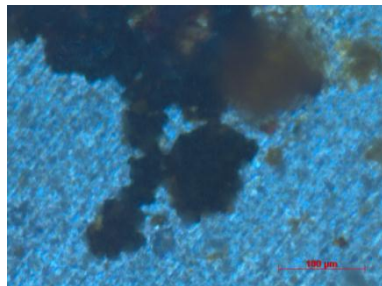
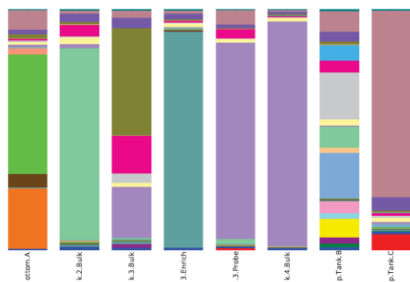


Biodiesel B20 Issues



Collaboration with Dr. Bradley Stevenson & Blake Stamps, OU

- quarterly field assessments
- microbiome analysis: liquid phases and biofilm
- enrichments/isolations
- in-tank and in-lab corrosion study
- metabolite analysis for fuel degradation (Sufлита lab)





Jet Fuel certification



- Certify 100% of fleet for bio-based aviation fuel by 2013
- 50% of fuel should be alternative fuel blends by 2025
- Many alternative fuels have already been certified

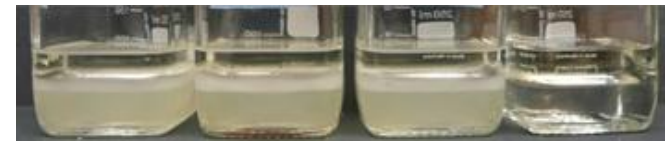
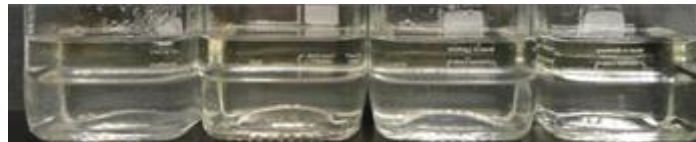
Current fuel certification process:

- includes materials compatibility testing
 - 33 metallic, 38 non-metallic materials
 - 28 day exposures, elevated temperatures (250°C)
- *may include* testing for microbial growth (O. Ruiz, AFRL/RQ)
 - co-inoculum: *B. licheniformis*, *P. aeruginosa*, *C. resinae*

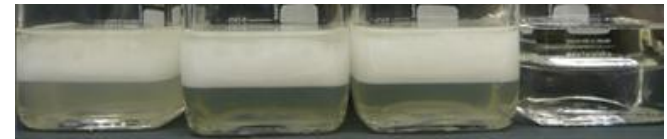
Day 2

Day 42

Jet A



Jet A/hydrorenewable
jet (HRJ) blend





Materials Susceptibility to Contaminated Alternative Fuel: APPROACH



MATERIALS, 2 phases:

- **non-metallics (2012-2013)**
 - coatings
 - bladder materials
 - sealants
 - insulating materials
 - hose materials
 - foam
- **metallics (2013-2014)**

EXPOSURES

- Jet A or Jet A/HRJ blend
- 1:1 mix of fuel:Bushnell-Haas medium
- Inoculum: enriched soil sample
- 60 day exposure
- Static @ 28°C, no medium exchange

ASSESSMENTS: ASTM standard methods

- Tensile
- Elongation
- Volume swell
- Hardness (Shore A and Pencil)
- Lap shear



Collaboration with Dr. Oscar Ruiz (AFRL/RQPF), Susan Mueller, Lisa Brown and Bill Fortener (Univ. of Dayton Research Institute)



Materials Exposures



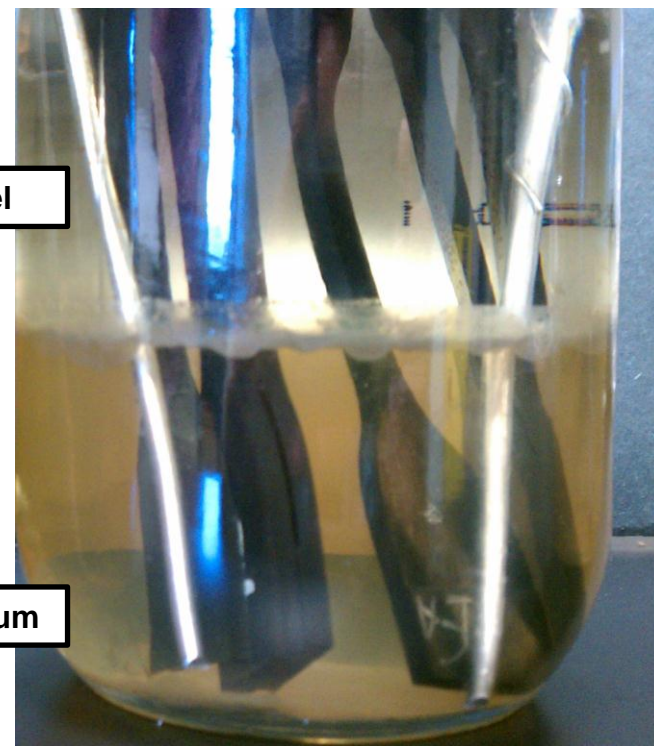
Volume swell specimens



Fuel

Medium

Tensile specimens

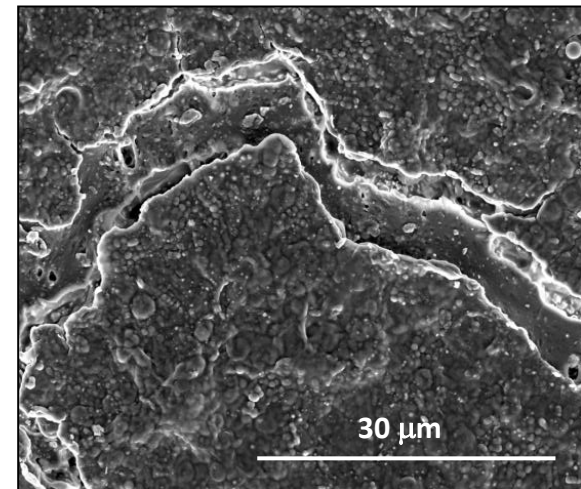
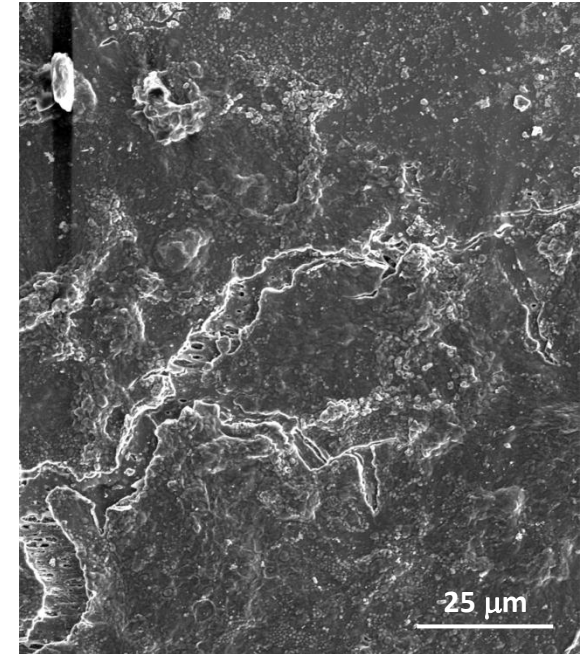
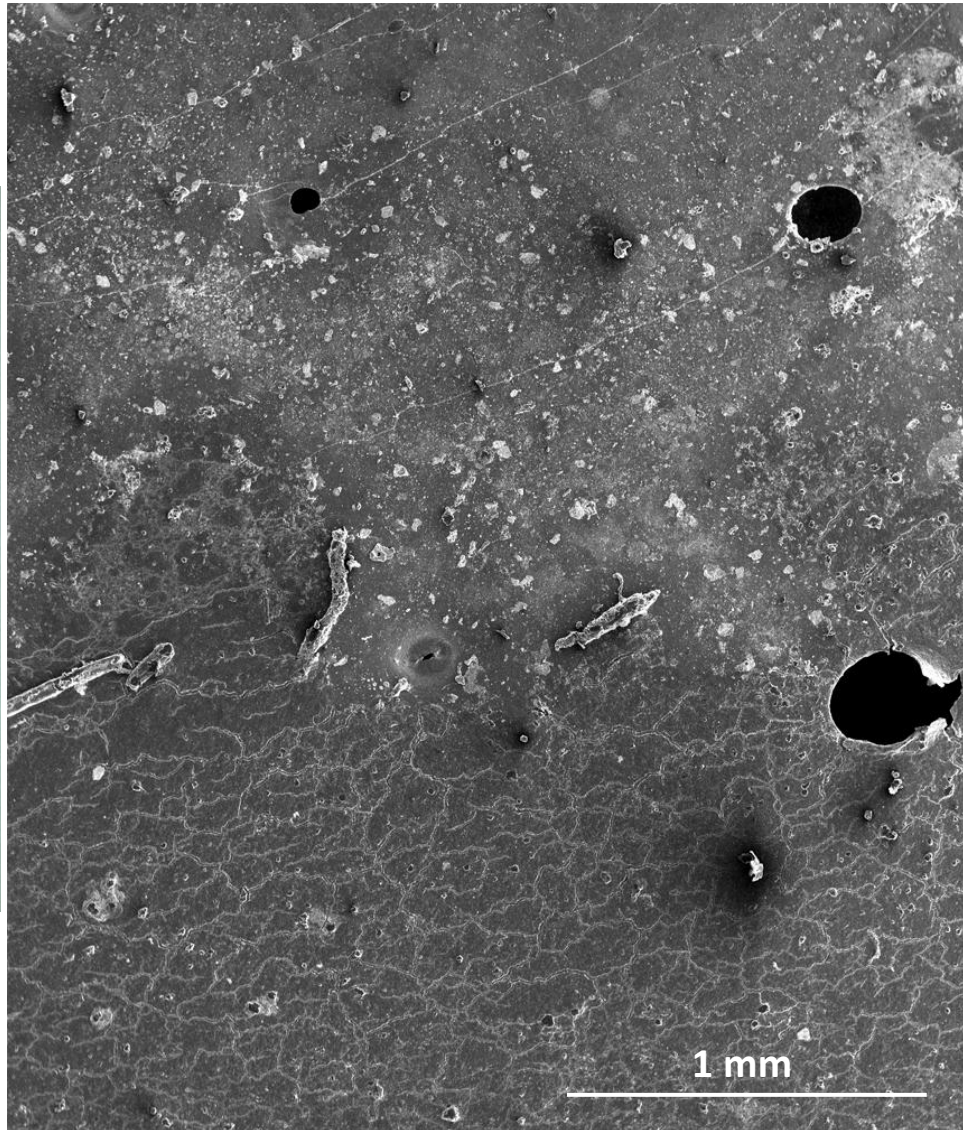




Material degradation at fuel:medium interface



Jet A
inoculated

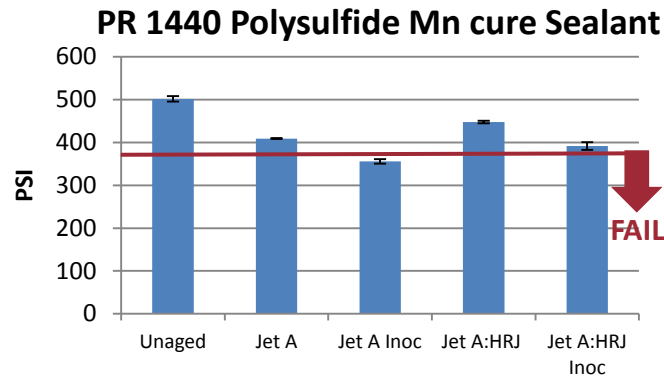




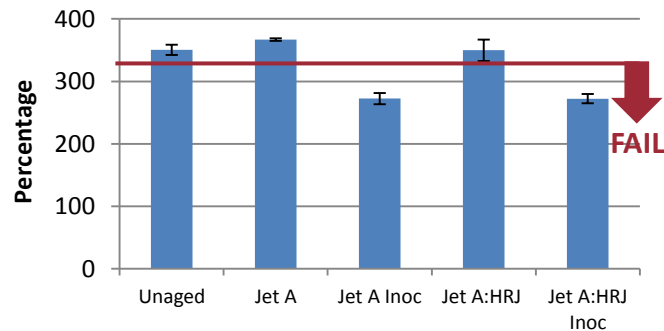
Results: Materials Testing



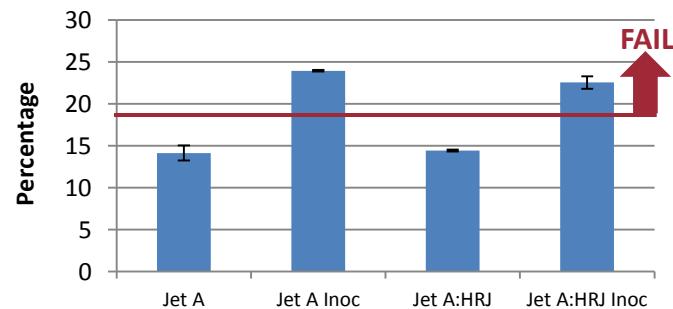
Tensile
(stress)



Elongation
(strain)



Volume swell





Materials Testing Results: Pass/Fail relative to uninoculated Jet A



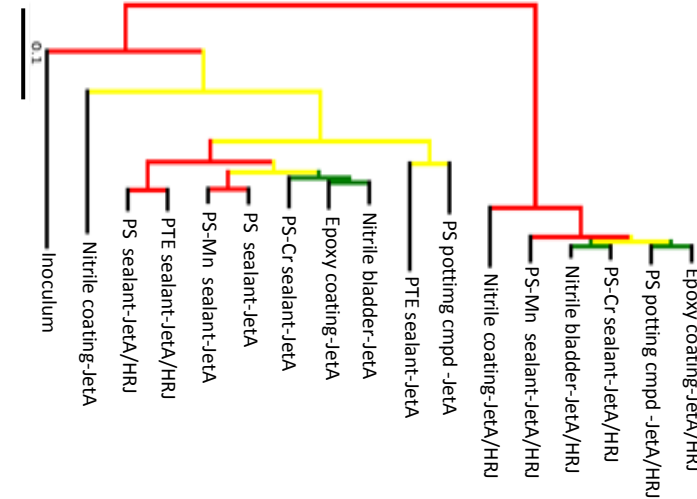
		inoculated	SEALANTS				BLADDERS		HOSE	WIRING INSULATION
			Polysulfide Mn cure	Polysulfide	Polysulfide DiCr cure	Fluorosilicone	Nitrile	Polyurethane	Acrylic Nitrile	Nylon
TENSILE	Jet A	+	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS
	JetA/HRJ	-	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS	PASS
	JetA/HRJ	+	PASS	PASS	PASS	FAIL	FAIL	PASS	FAIL	PASS
ELONGATION	Jet A	+	FAIL	FAIL	FAIL	PASS	PASS	PASS	PASS	PASS
	JetA/HRJ	-	PASS	PASS	PASS	PASS	PASS	PASS	PASS	FAIL
	JetA/HRJ	+	FAIL	FAIL	FAIL	PASS	PASS	FAIL	PASS	FAIL
VOL SWELL	Jet A	+	FAIL	FAIL	PASS	PASS	FAIL	FAIL	PASS	NA
	JetA/HRJ	-	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	NA
	JetA/HRJ	+	FAIL	FAIL	PASS	PASS	PASS	FAIL	FAIL	NA



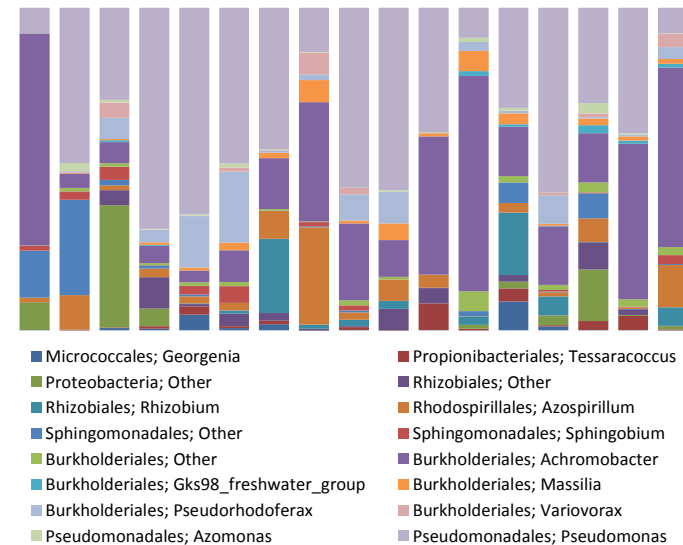
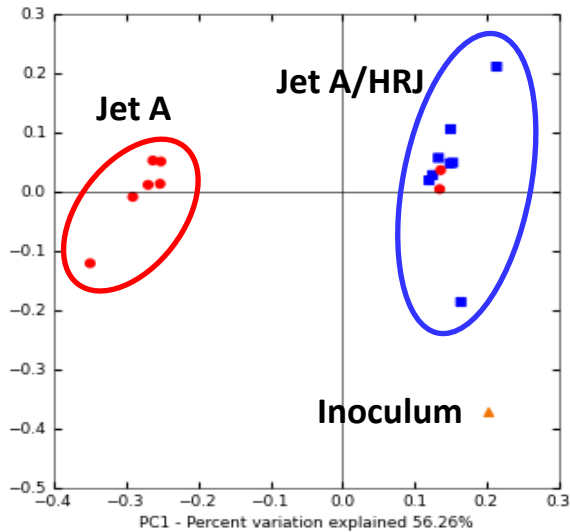
Microbiome Analysis



- DNA extracted from biofilms formed on materials
 - 4 sealants (3 polysulfide, 1 polythioether)
 - polysulfide electrical potting compound
 - 2 coatings (nitrile and polyimide epoxy)
 - nitrile bladder material
- Amplification of 16S rDNA, 454 seq, QIIME



Fuel type dictates community membership



QIIME analysis by Dr. Brad Stevenson and Blake Stamps, OU



What's Next?



- **Are *Achromobacter piechaudii*. and/or *Pseudomonas stutzeri* necessary and sufficient to cause material degradation?**
 - 2 polysulfide sealants will undergo further analysis
 - Inocula:
 - *A. piechaudii* alone
 - *P. stutzeri* alone
 - *A. piechaudii*/*P. stutzeri* co-inoculum
 - Original soil enrichment
- **Mechanism of degradation to be investigated by FTIR, XPS**





Summary



- **Rates and frequency** of biocorrosion in the AF are poorly understood.
 - field studies underway
 - increasing awareness amongst maintainers
- ‘Green’ initiatives in **alternative fuels** and **non-Cr material systems** have the potential affect biocorrosion rates.
- AFRL is taking proactive approach to understanding the potential impact of these initiatives.
 - Of **22** polymeric materials tested, **at least 3** were negatively affected by inoculated fuel; **5** more were negatively affected by HRJ/Jet A and/or microbes.
 - Fuel type, not material type, determined microbial community associated with the material.
 - Mechanism of polymer degradation will be investigated.
 - Metals in phase II



Acknowledgments



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- Lloyd Nadeau
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- Susan Mueller
- Lisa Brown

University of Dayton Research Institute

- Bill Fortener
- David Claiborne

University of Oklahoma

- Dr. Bradley Stevenson
- Blake Stamps

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