Synthesis of Iron Oxide Nano Particles for Structural Health Monitoring Sensors

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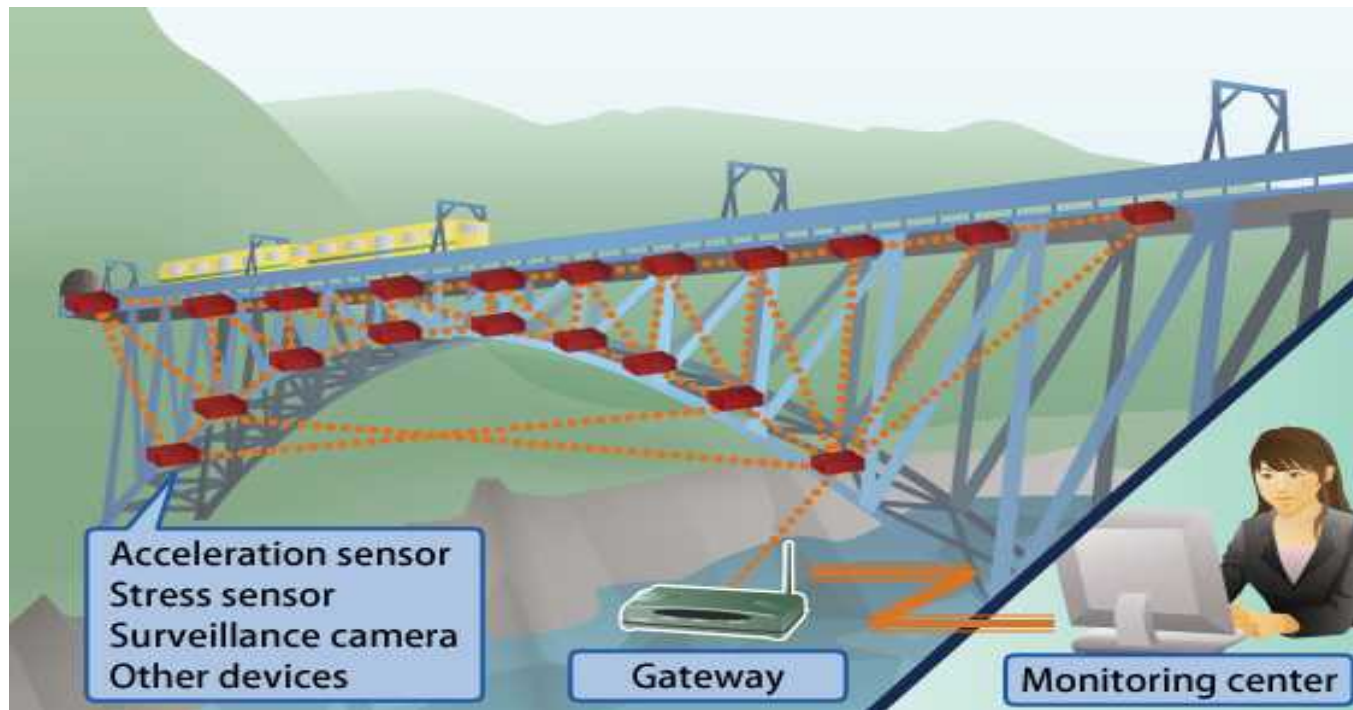# Structural Heath Monitoring of MHK Composite Materials

Remote monitoring of underwater structures made of composite fiberglass material

- 100 year storm ocean wave weakens structure?
- Boat runs into device?
- Operation monitoring?
- Detect cracks, resin failures, debonding?

Structural Health Monitoring

- With the help of non-destructive inspection, SHM helps detect damage done and monitors the health of a material through sensors embedded within the material.

Acceleration sensor
Stress sensor
Surveillance camera
Other devices
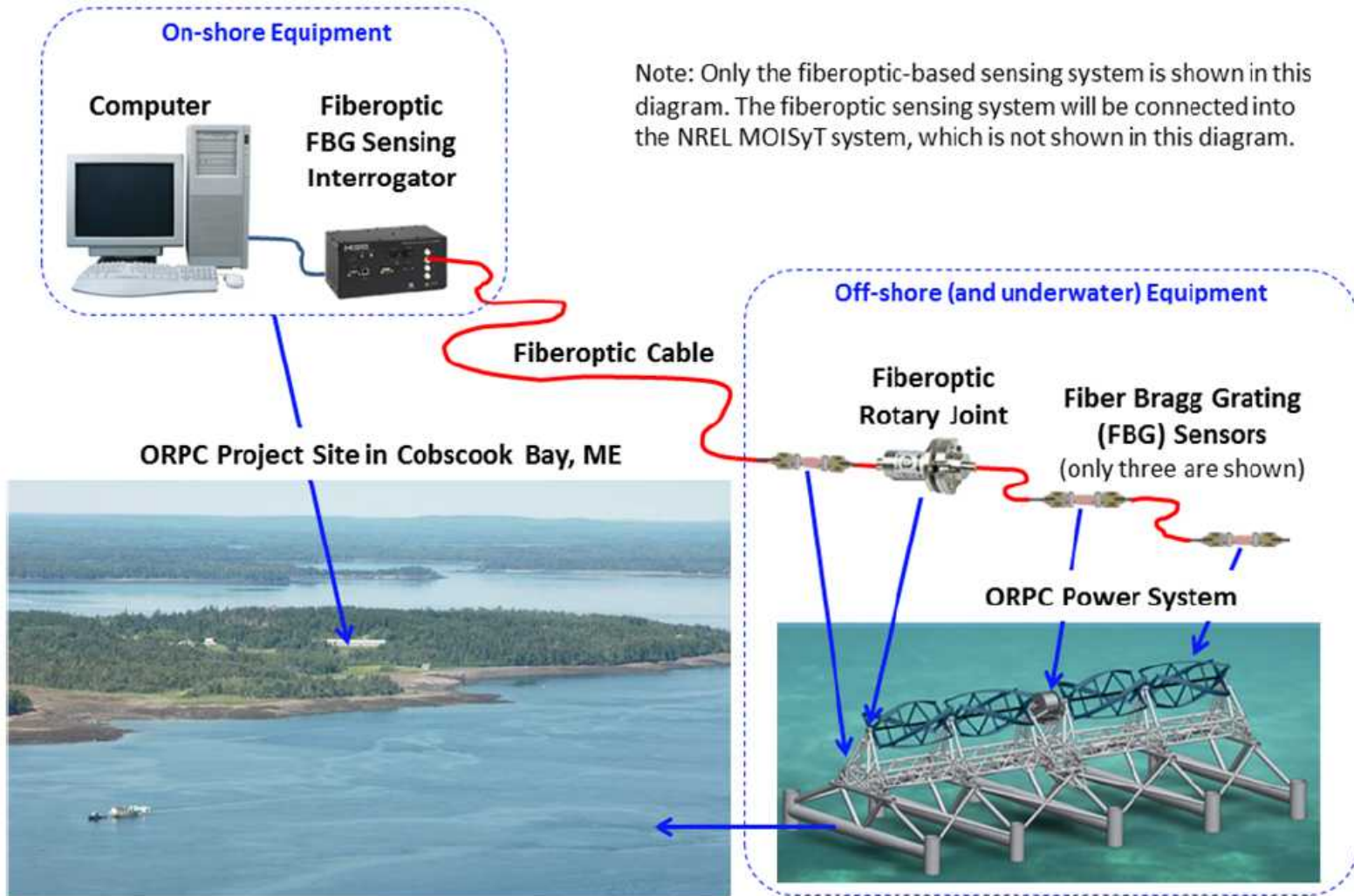
Gateway

Monitoring center

MHK Monitoring

Figure 1 – Concept diagram of a fiberoptic-based sensing system for the ORPC MHK application.

Developing Novel Fiber Composite Sensors for Structural Health Monitoring

Current Strain Gauge Sensors
Based on fiber optics

Micron Optics, Inc.
os1100 uncoated/recoated
~150μm diameter

Large fibers, one time use, and can act as a defect site

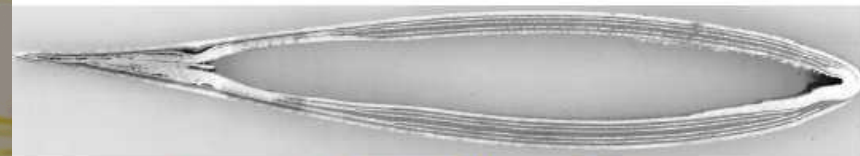Figure 2 – Section of an ORPC-supplied foil, from which coupon substrates were cut.

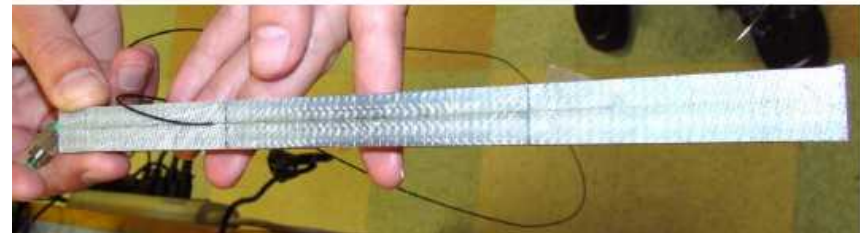Figure 3 – Cross-section of the ORPC-supplied foil showing the laminate layup.

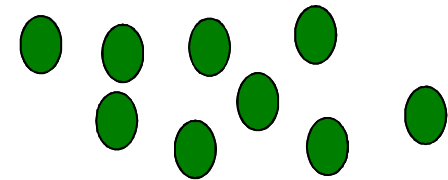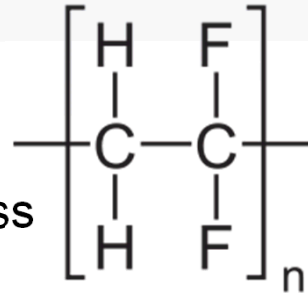Figure 4 – Test specimen with a mounted MOI bare FBG sensor.

Figure 5 – Test specimen with a mounted MOI standard-package FBG sensor.

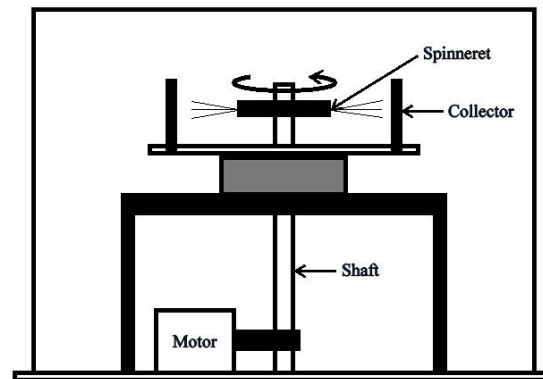# Goal: to develop novel structural health sensors
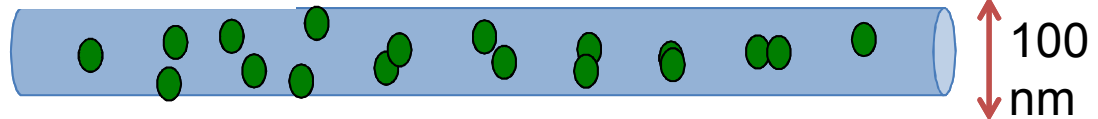
PVDF= Polyvinylidene fluoride
Piezoelectric polymer
Produces charge with mechanical stress

Magnetic Nanoparticles
Fe_2O_3 (5-10 nm)

Spinneret

Collector

Shaft

Motor

Force Spun Fiber Sensor

100 nm

Combined polymer & Nanoparticles will be force spun into fibers that can be embedded into composite layup
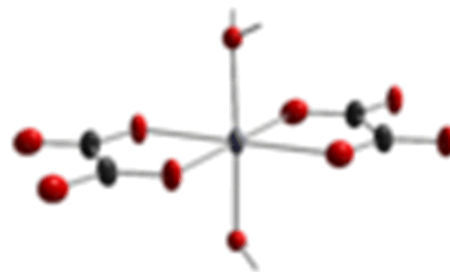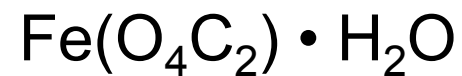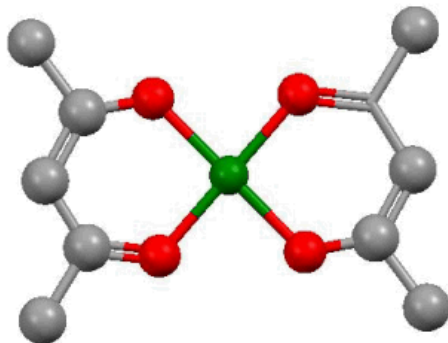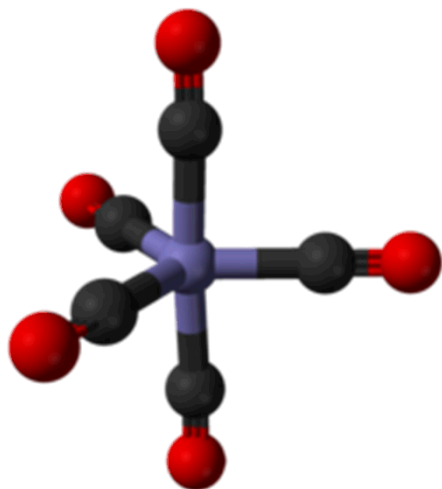
Safety in the Lab

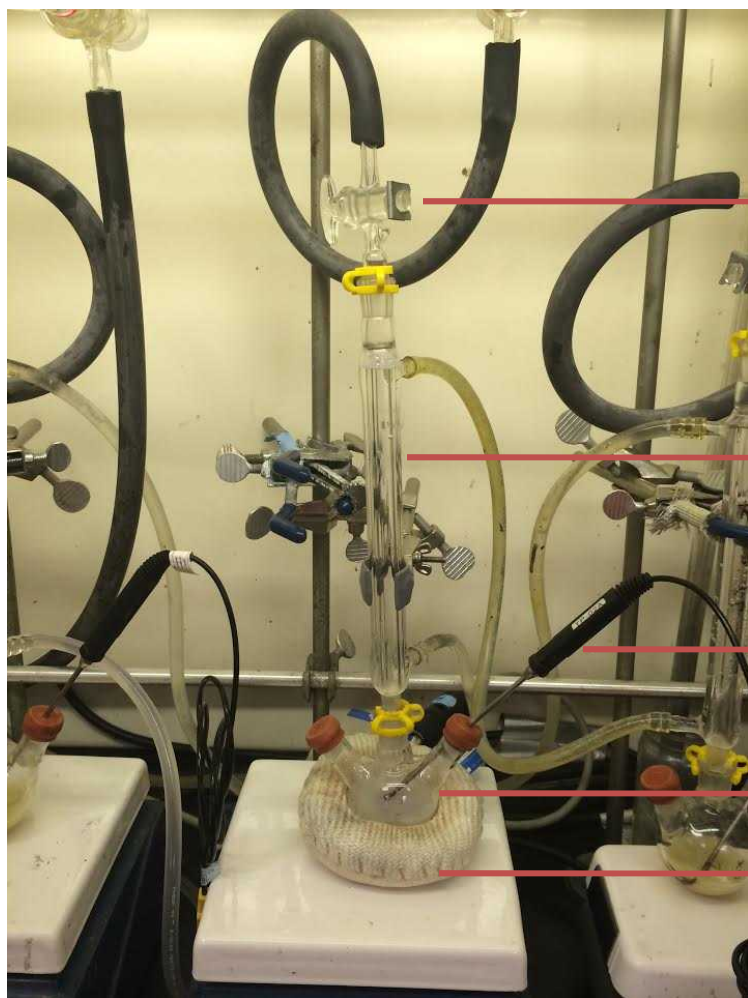- Always wear PPE when dealing with chemicals inside the lab

- ESH100, AML101, BEA100, CHM100, ENV112, NANO101, Cryogen Safety, and Pressure Safety
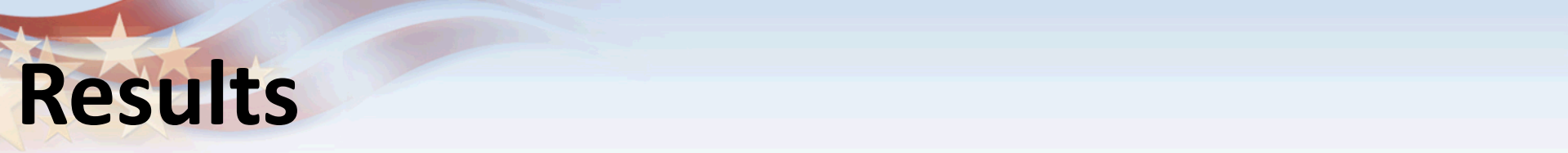
Precursors Used

Fe(CO)$_5$ Fe(acac)$_2$ Fe(O$_4$C$_2$) • H$_2$O

Experimental Setup

Stop cock

Condenser

Thermocouple

3 neck round bottom

Heating mantle

Results

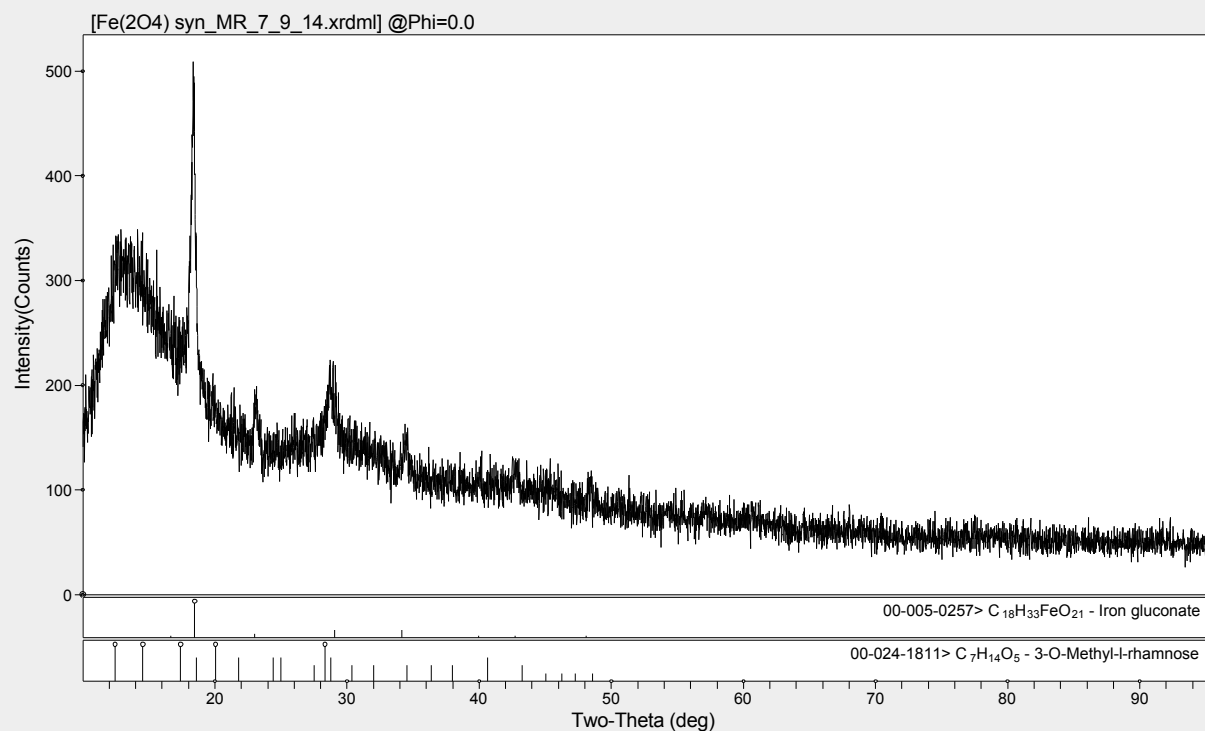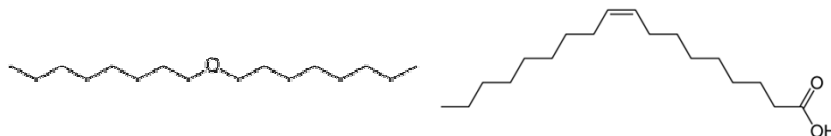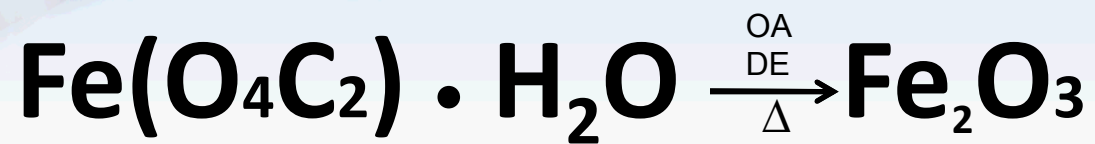| Precursors	Solvent	Time and Temp.	Characterization	Appearance of Product	Product
$Fe(AcAc)_2$	Oleic Acid	4hrs 200°C	XRD	Dark liquid	amorphous
$Fe(AcAc)_2$	Dioctyl Ether + Oleic Acid	4hrs 200°C	XRD	Dark liquid	amorphous
$Fe(O_4C_2) \cdot 2H_2O$	Dioctyl Ether + Oleic Acid	6hrs 286°C	XRD, FTIR	Small green solid particles	FeO_4C_2
$Fe(CO)_5$	Dioctyl Ether + Oleic Acid	4hrs 290°C	XRD	Dark liquid	Fe_2O_3

Characterization Setup

FT-IR: instrument that characterizes
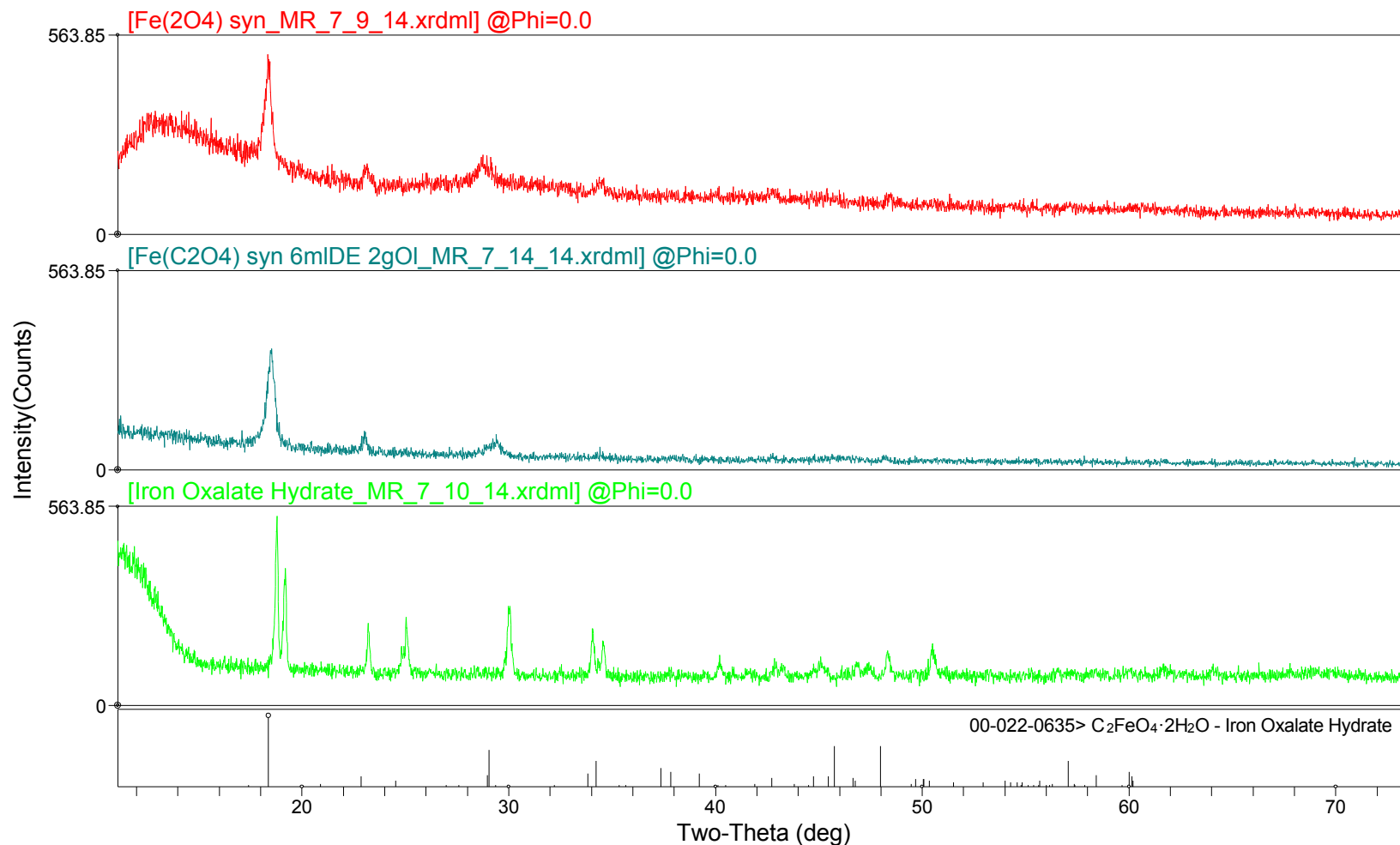the functional groups of a product

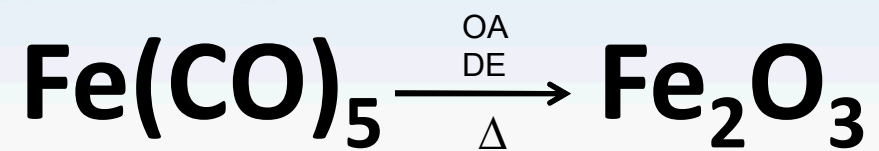Transmission Electron Microscopy (TEM): characterizes crystallographic shapes and size

PXRD: instrument that characterizes
the crystallization of a product
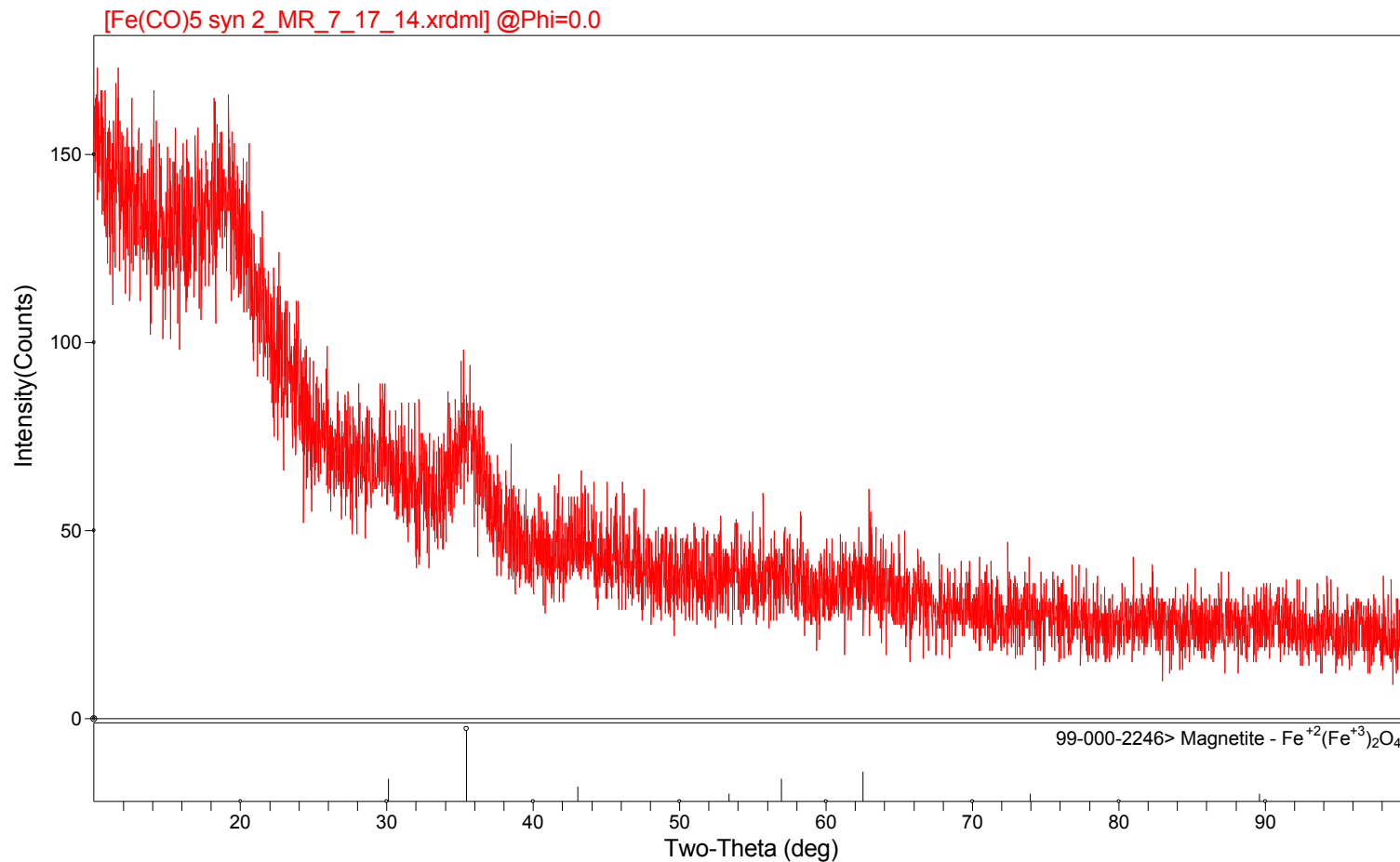
Fe(O₄C₂) • H₂O $\xrightarrow[\Delta]{\substack{OA \\ DE}}$ Fe₂O₃

[Fe(2O4) syn_MR_7_9_14.xrdml] @Phi=0.0

00-005-0257> C$_{18}$H$_{33}$FeO$_{21}$ - Iron gluconate

00-024-1811> C$_7$H$_{14}$O$_5$ - 3-O-Methyl-l-rhamnose

XRD Results

$$\text{Fe(CO)}_5 \xrightarrow[\Delta]{\substack{\text{OA} \\ \text{DE}}} \text{Fe}_2\text{O}_3$$

Fe(CO)₅ XRD Results

[Fe(CO)5 syn 2_MR_7_17_14.xrdml] @Phi=0.0

99-000-2246> Magnetite - $Fe^{+2}(Fe^{+3})_2O_4$
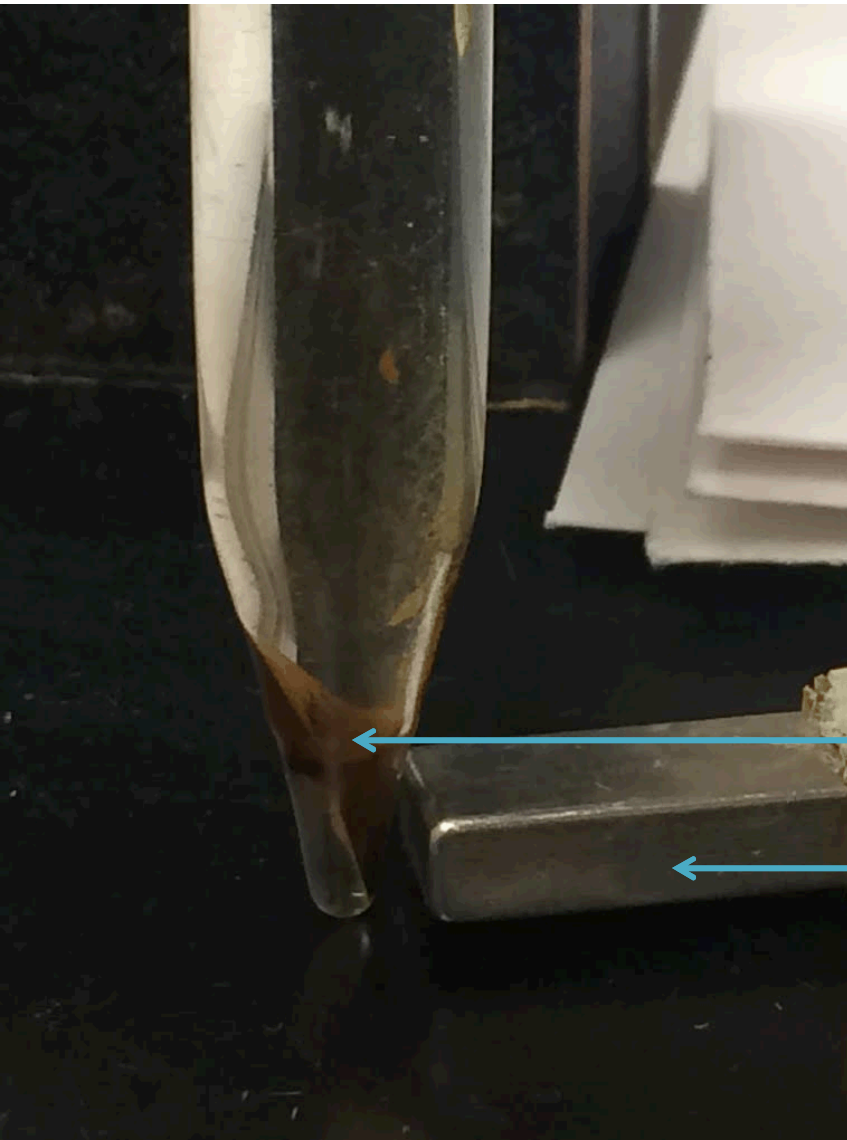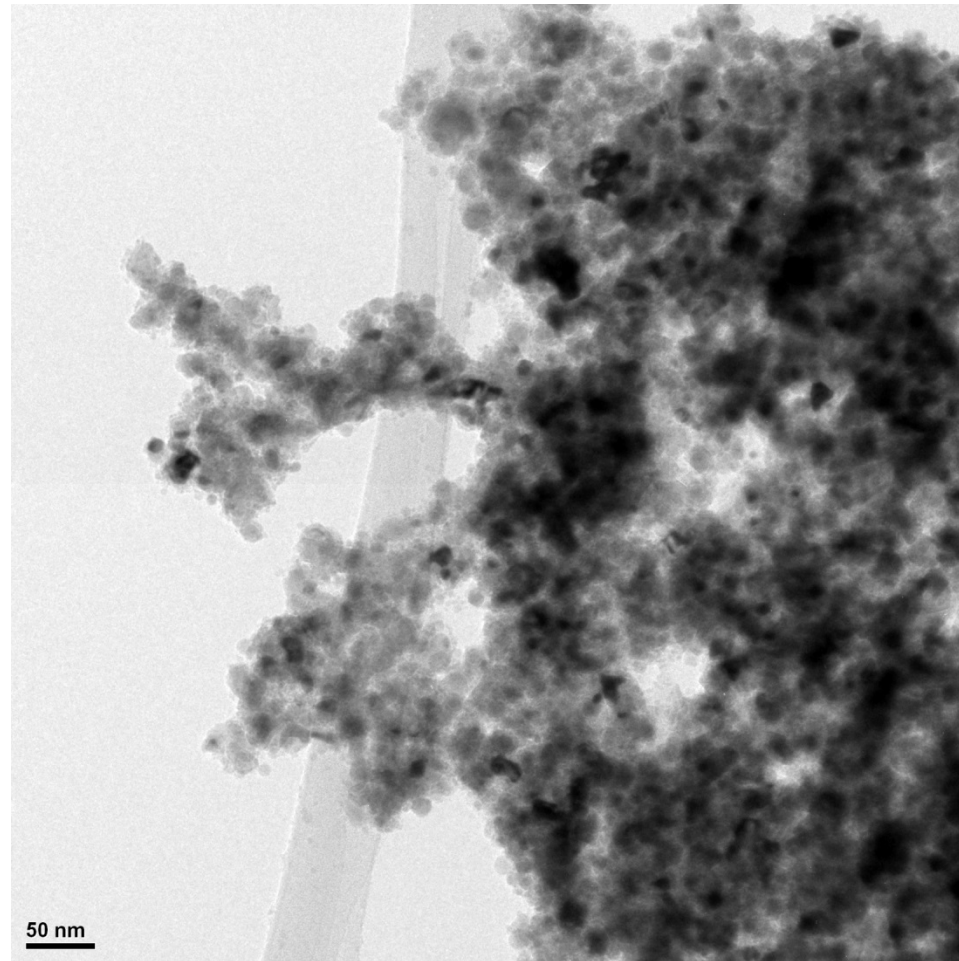
Magnetic

Iron oxide nano particles

Rare earth magnet

TEM

What I learned

- FT-IR
- RAMAN
- The importance of SHM and non-destructive inspection
- Solution precipitation method
- Safety precaution in any lab
- Some presentation skills
- More chemistry than I ever learned in school