Growing Al-Tobermorite Fibers for Concrete

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Introduction:

- Average lifespan of today's concrete: ~100 years
- Examples of 2000 y/o Roman concrete still standing today [2]
- Durability may be from Al-Tobermorite [2]
- One morphology of Al-Tobermorite is fibrous [1]
- Microfiber reinforced concrete exhibits higher strength and durability
- Fibers grown in-situ could increase durability of concrete without limiting workability

Objectives:

Overall:

- Grow Al-Tobermorite in Portland cement samples

Semester:

- Recreate the Al-Tobermorite fibers in Maeda paper [1] (Figure 1)
- Learn how and why the fibers grow for practical application in Portland Cement

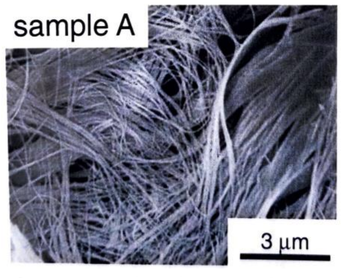

Figure 1: Al-Tobermorite fibers grown by Maeda

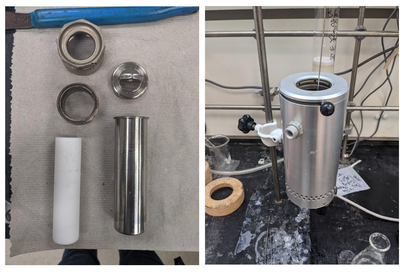

Figure 2: Pressure vessel and tube furnace

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Experimental:

- Ca/(Al+Si)=0.83; Al replaced 5 mol % Si
- Mass Ratio of Water:Solids was manipulated
- Samples were hydrothermally reacted in a pressure vessel at 180 °C for ~48 hours (Figure 2)
- XRD and SEM Analysis was completed on products (Figures 3-6)

Results:

- XRD showed clear $Ca(OH)_2$ and SiO_2 peaks
- Absence of Tobermorite peaks
- Absence of Al_2O_3 peaks could mean presence of calcium aluminates
- SEM showed evidence of fibrous, platy, and geometric morphologies

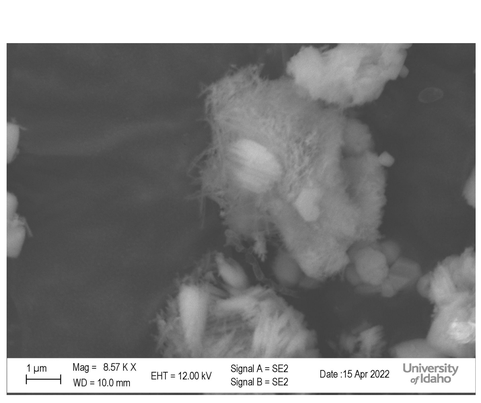

Figure 3 – 10:0.27 Water:Solids

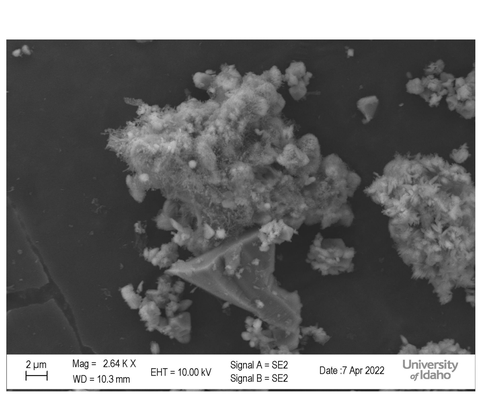

Figure 4 - 10:1 Water:Solids

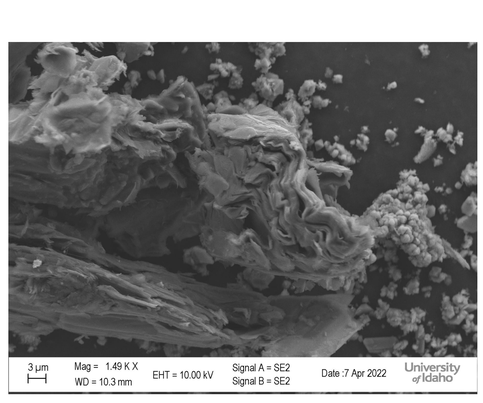

Figure 5 – 10:3.75 Water:Solids

Expected peak here for Tobermorite

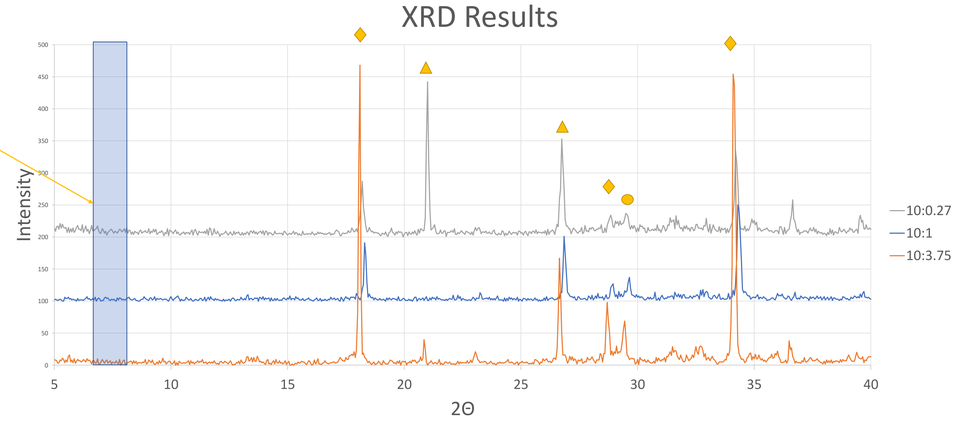

Figure 6: XRD Analysis

- ◆ Denotes $Ca(OH)_2$ peak
- ▲ Denotes SiO_2 peak
- ● Denotes Probable $CaCO_3$ peak

Conclusions/Lessons Learned:

- Failed to synthesize Tobermorite
- Not enough SiO_2 in solution even after 48 hours
- Surface Area of SiO_2 important for dissolution
- Impurities in SiO_2 source could have impacted results
- Mass fraction did affect morphology

Future Work:

- Repeat with pure SiO_2 with high surface area (fumed silica)
- Repeat with fibrous Al_2O_3 and SiO_2 as seeds
- Grow Tobermorite in lower temp reaction
- Experiments in Portland Cement

References: [1] Maeda, et al, JCS-J 119 [5] 375-377 (2011); [2] Jackson M.D., et al, PNAS 111 [52] 18484-18489 (2014)