



Oil Water Separation Using Titania-Coated Filter

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Introduction

The Huntington Beach Oil Spill was detected in October 2021. The leakage, caused by a split in an underwater pipeline, spilled 126,000 gallons of crude oil into coastal waters

Our solution focuses on being cost-effective and environmentally friendly



Objectives

Utilizing the oleophobic and hydrophilic properties of titanium dioxide, develop a cost-effective coated filter that is more efficient for cleaning oil spills

Compare the efficiency of multiple treatment methods in titanium dioxide coated filter preparations

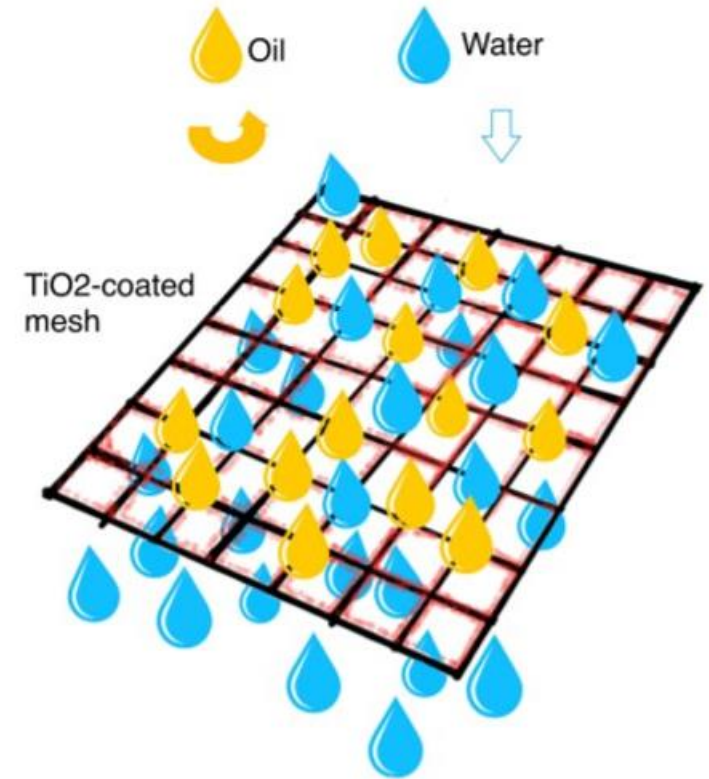


Figure 1.

A modified coated filter that repels oil while allowing seawater to pass through.

Current Methods

Burning

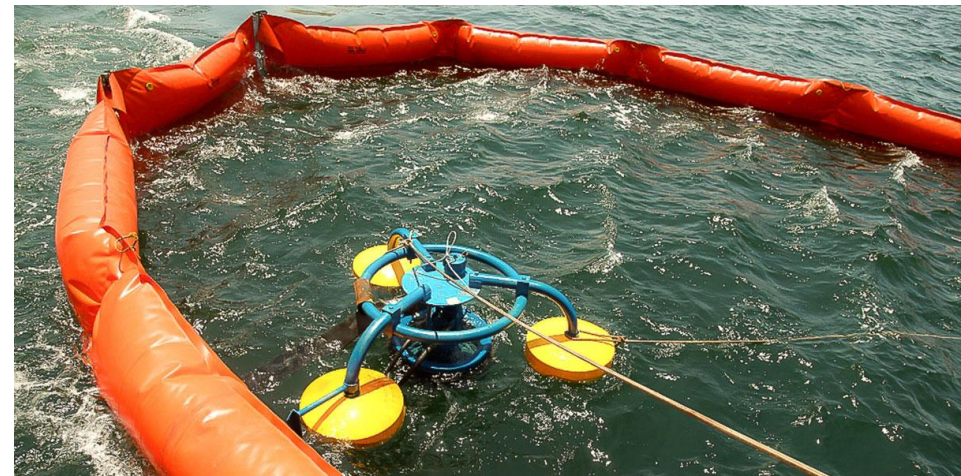
- Requires ideal wind and sea conditions
- Can potentially adversely effect people/wildlife

Dispersion

- Potentially harm wildlife on the seafloor
- Winds can redirect chemical spray

Skimming

- Requires calm ocean surface
- Has high potential for improvement via coated filters

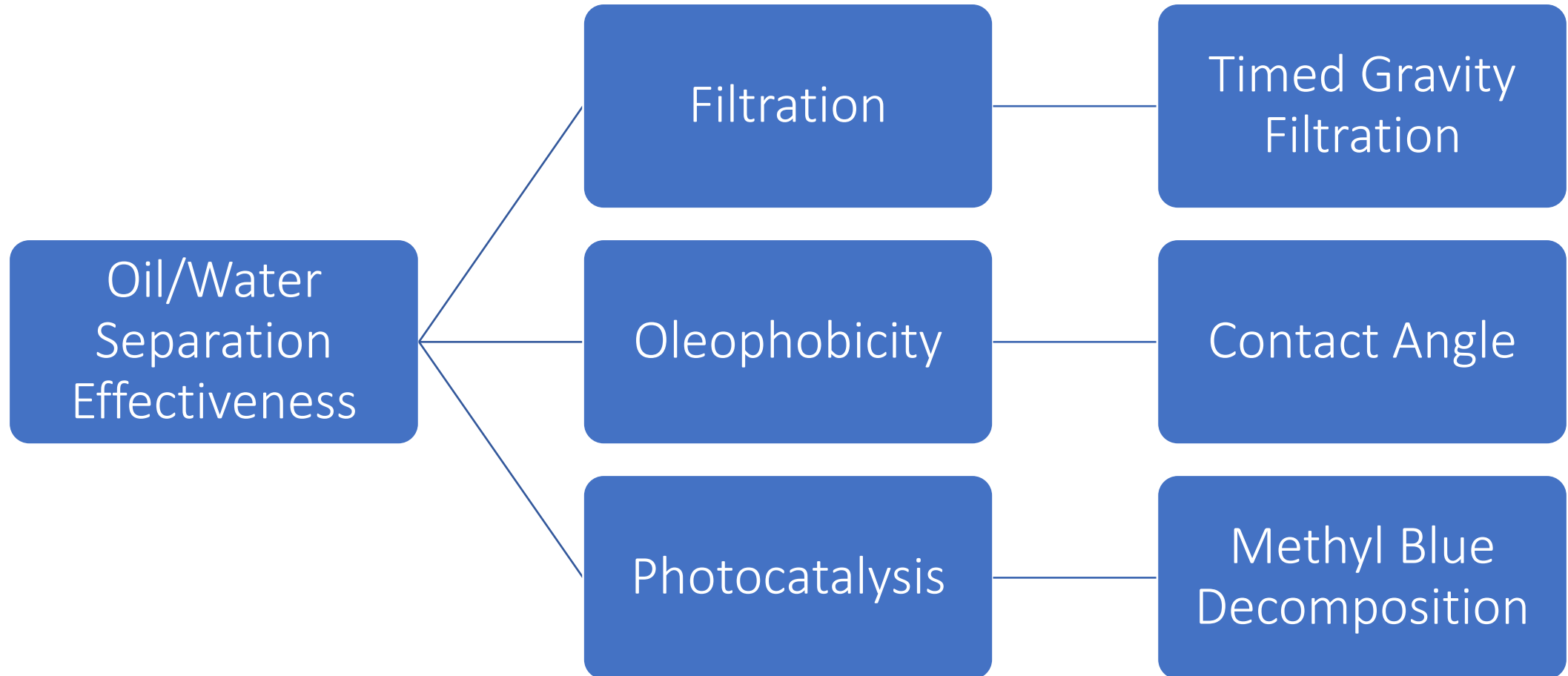




Background

- The inspiration for this project comes from self-cleaning window coatings
- Self-cleaning refers to three critical properties that will be useful in filters
 - Oleophobicity
 - Hydrophilicity
 - Photocatalysis

Methodology



Cost Optimization

The materials used were intended to be cost effective to allow for easy accessibility

A relatively simple synthesis/treatment using non-sophisticated materials for a straightforward reproduction

Materials/Equipment

Titanium (IV) Isopropoxide (TTIP): TiO_2 Precursor

Acetic Acid

1-Butanol

Substrates: Thick paper (coffee filters), Sheets of Undyed Cotton

Microwave (1000W)

Refrigerator

Ultra-Sonicated Bath

Treatment Methods

To create filters more effective in oil/water separation we introduce three methods

Microwave

Refrigeration

Sonication



A treatment is needed to obtain

Smaller nanoparticles size and Anatase TiO_2

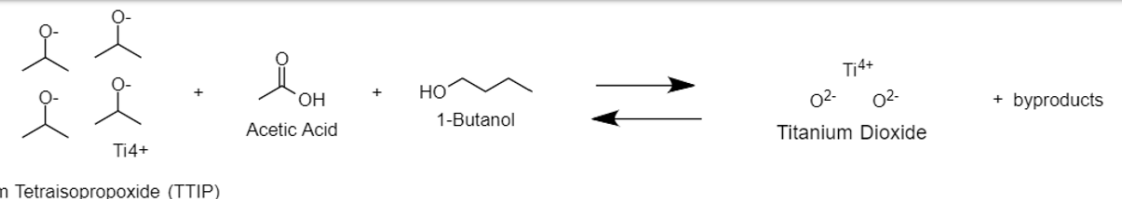
- Both properties enhance oleophobicity and photocatalytic activity



Sol-Gel Preparation

- Solution 1: Slowly add TTIP into 1-Butanol while mixing for 30 min
- Solution 2: Dropwise add acetic acid into Solution 1 while mixing for 120 min

Exothermic reaction. Conditions are under a fume hood or well-ventilated area at room temperature





Treatment Method: Microwave

- Microwave heats the volume of solution evenly
- Reaction rate of process forming TiO_2 particles increases
- Produces high yield for the cost of materials

Procedure:

- Microwave sol-gel coated substrate at 1000 W for 3 minutes
- Allow coated filter to dry at room temp for 24 hours



Treatment Method: Refrigeration

- A lower treatment temperature leads to a smaller crystalline size for TiO_2 .
- Lowest treatment temperature compared to other methods
- Smaller crystal size $\rightarrow$ Larger surface area to volume ratio

Procedure:

- Immerse the filter completely in the sol-gel
- Store the immersed substrate in a refrigerator at 4°C for 24 hours
- Let the filter dry at room temp for 24 hours



Treatment Method: Sonication

- Cavitation creates temperatures $>5000\text{K}$ and pressures $>20\text{ MPa}$ in a localized area
- Enhances creation of metal oxide and nanoparticles
- Leads to the formation of crystalline titanium dioxide without additional heating

Procedure:

- Immerse beaker containing sol-gel into ultrasonic bath
- Sonicate for a total of 20 minutes
- Immerse substrates into sonicated solution
- Allow filters to dry at room temperature for 24 hours

Timed Oil Filtration Test

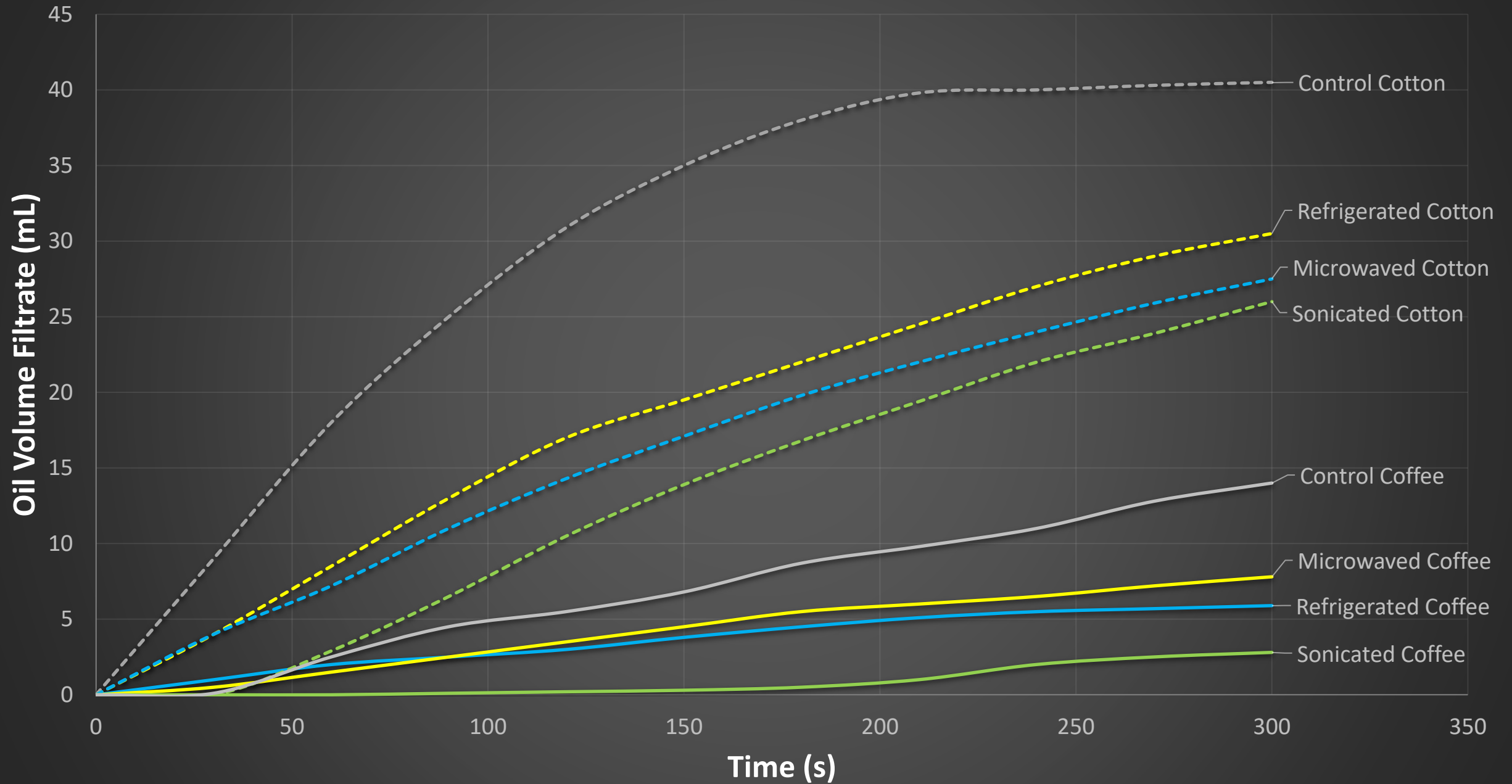
Reasoning:

- Treated filters are expected to reduce volume of filtrate
- Gives quantifiable value to filtration capability
- Allows for the comparison of filtration efficiency between filters

Procedure:

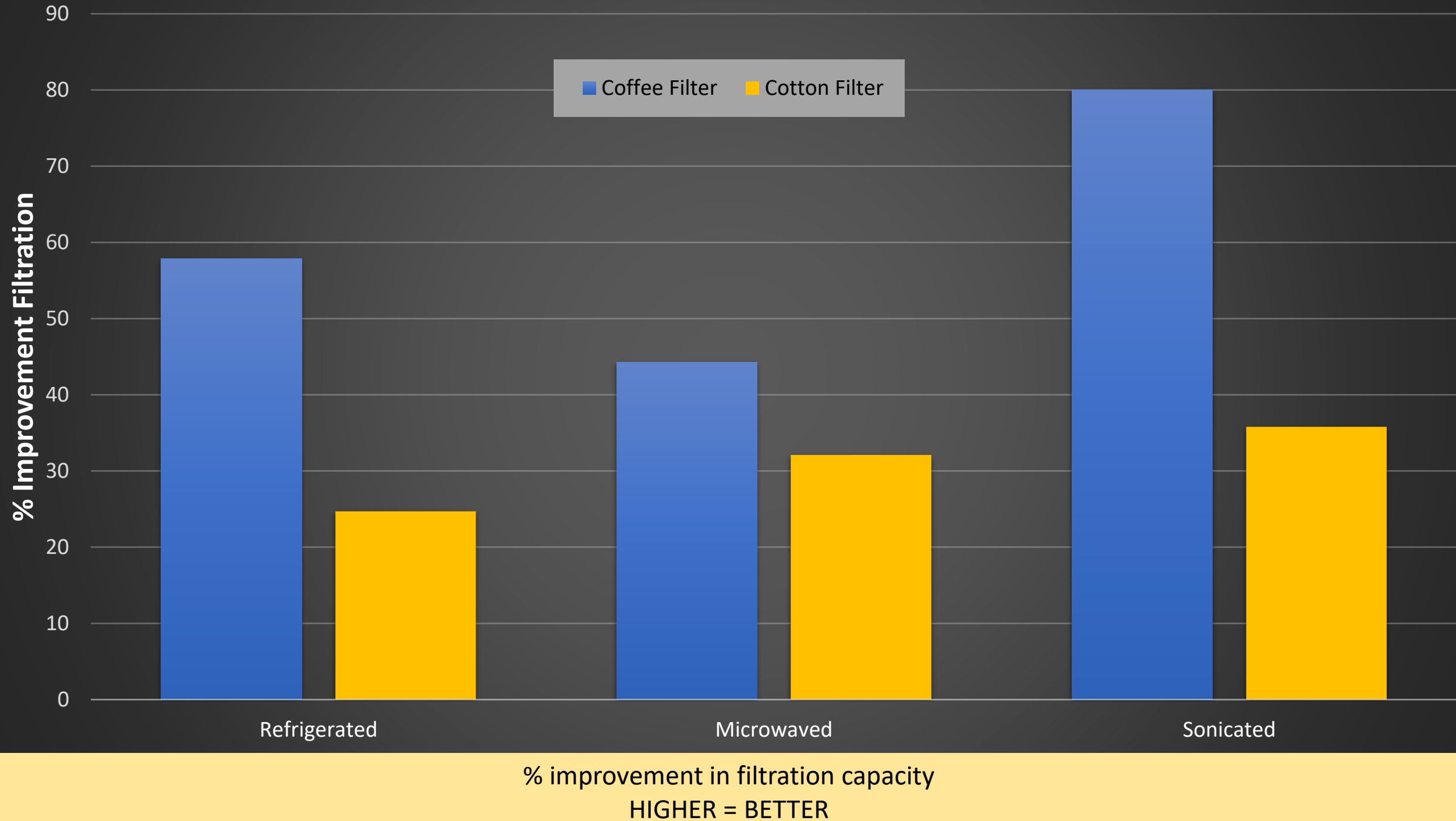
- 50 mL of motor oil was poured onto the filter and allowed to run for 5 minutes
- Volume of oil pass-through measured in 30 second intervals





Filtration ability of treated filters vs. control

LOWER = BETTER



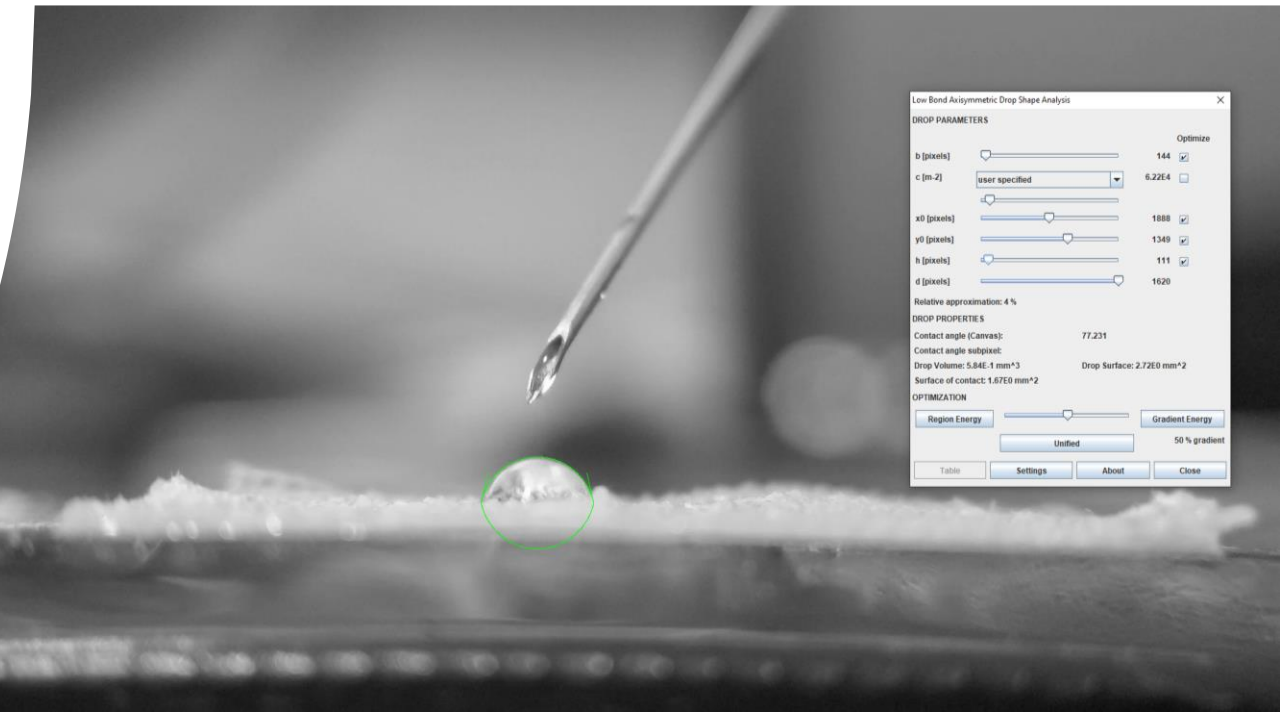
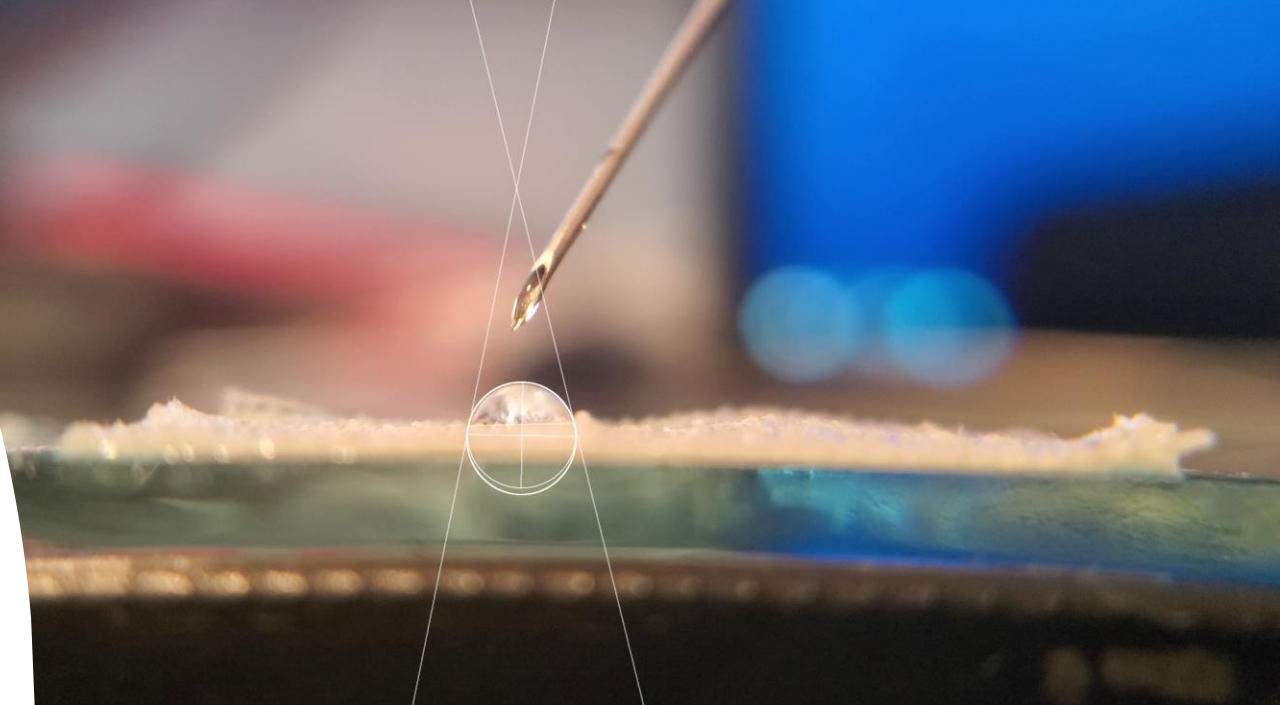
Static Contact Angle Test

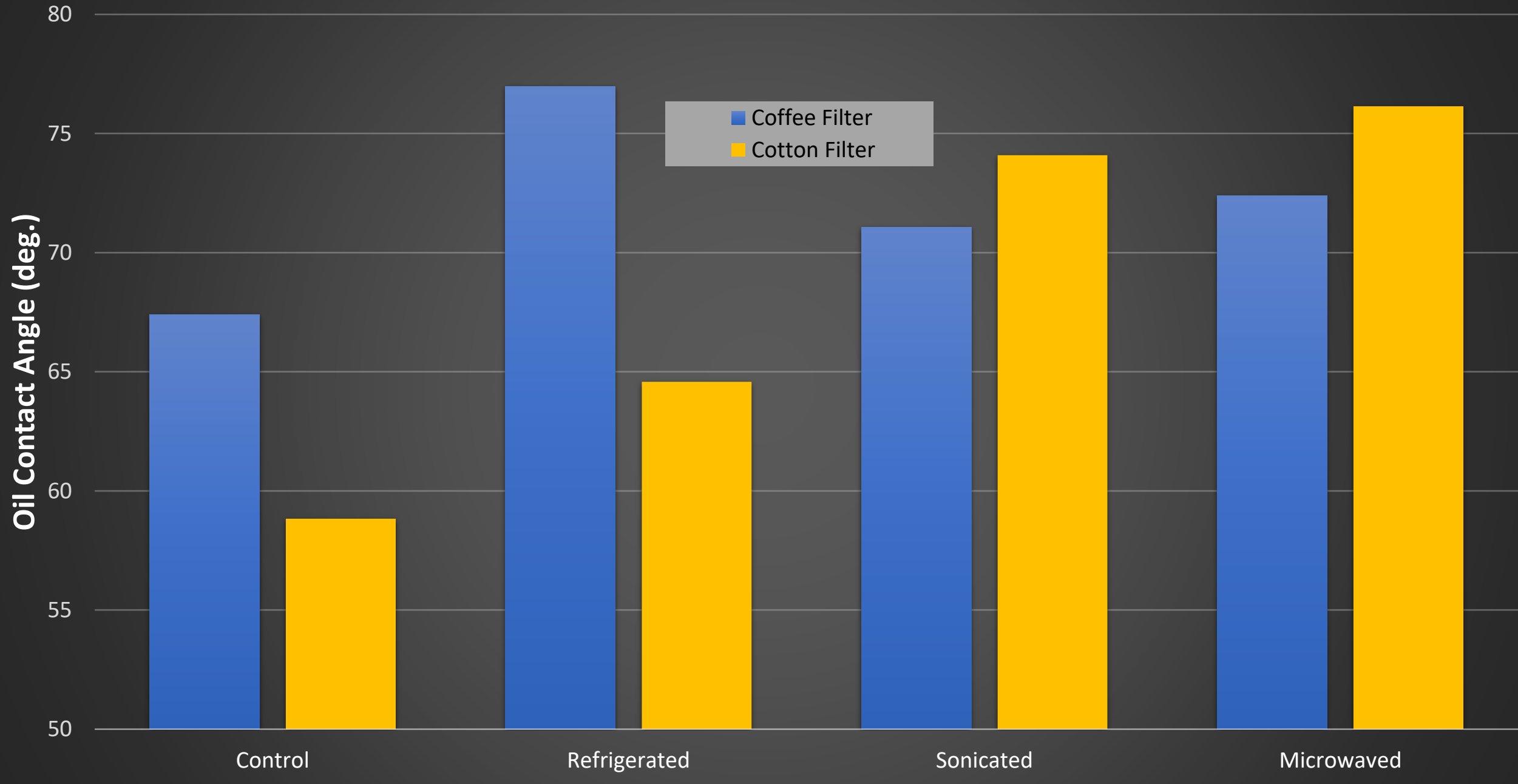
Reasoning:

- Higher contact angle indicated enhanced oleophobicity
- The static contact angle for treated is expected to be higher than untreated
- Contact angle shows the filters resistance to being wetted with oil

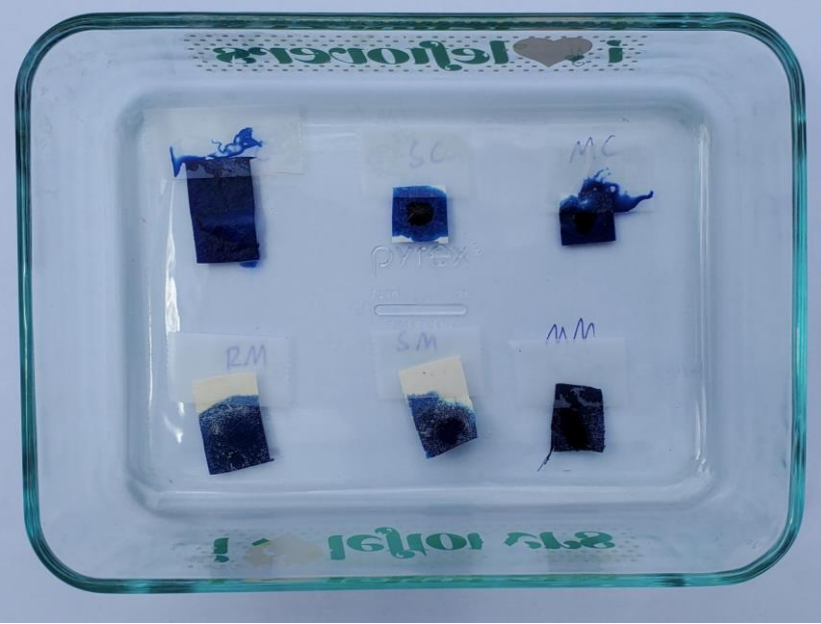
Procedure:

- A macro video was recording, an oil droplet being placed onto the filter
- Image of the droplet on first contact with the filter is captured from video

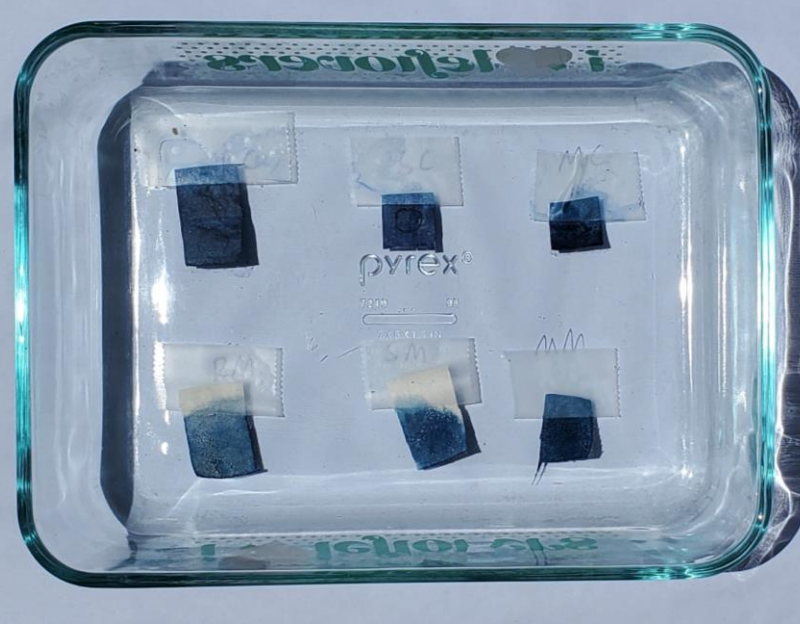




Static oil contact angle of oil droplet on filters
HIGHER = BETTER



t = 0 hours



t = 10 hours



t = 20 hours

Photocatalytic Analysis

- Methyl blue (MB) was applied to TiO_2 coated strips of the filter
- Color of MB degrades under exposure to UV light in the presence of a photocatalyst
- Proof of photocatalysis confirms that the filter fulfills one of the self-cleaning properties

Conclusions



TiO₂ coating on filters increase capability in oil/water separation



Sonication has the most profound effect on filtration



Oleophobicity improves greatly for less porous substrates



Future Work

- Pretreating fabric to improve titanium dioxide adhesion
- Improve practical implementation of the filter using additional layers of coated substrates
- Explore additional less porous substrates

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Questions?

Please feel free to email me your questions:

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