The Effect of Rigid Agarose Microemulsion Hydrogels on Reducing Stains from Xuan Paper Mounted Structures

Part I: The swelling effect of different concentrations of agarose microemulsion rigid gels on 15% PVA AYAA in ethanol.

Description:

The swelling of each PVA glass slide will be used as a qualitative measurement of which agarose concentration and microemulsion mixture would have the most swelling power.

Research questions:

- How do we make a microemulsion hydrogel? Does it work? What are the agarose concentration limits?
- How much does each microemulsion hydrogel swell the 15% PVA AYAA in ethanol?
- Figure out at what temperature the different concentration of gels want to "hang out" at in a water bath.

Materials

- Twenty 15% PVA AYAA in ethanol; painted out on glass slides. Two layers of PVA was applied[1]
- 4%, 6%, 8%, and 10% agarose gel
- Microemulsions (See *Microemulsions to Try*)

Microemulsions to Try:[2] [3]

1. EAPC Fluid -ish
    a. Water 73.3 and propylene carbonate 8 = continuous phase
    b. Ethyl acetate 8 = nanosized ellipsoidal droplets
    c. 1-pentanol 7 and SDS 3.7 = dispersed phase

Mixing procedure:

1. Measure deionized water.
2. Dissolve surfactant (SDS) in water.
3. Add propylene carbonate dropwise.
4. Add 1-pentanol dropwise.
5. Add ethyl acetate dropwise.
6. Let the microemulsion sit for at least a day before use.

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[1] The PVA solution selected has a high molecular weight, therefore water in the hydrogels will have less of an effect on the swelling. The PVA concoction was made in 2016 or prior.

[2] Bonelli, Nicole, Costanza Montis, Antonio Mirabile, Debora Berti, and Piero Baglioni. 2018. "Restoration of Paper Artworks with Microemulsions Confined in Hydrogels for Safe and Efficient Removal of Adhesive Tapes." PNAS (2018). https://www.pnas.org/doi/10.1073/pnas.1801962115

[3] Measurements deduced from…? *Ask Matt*

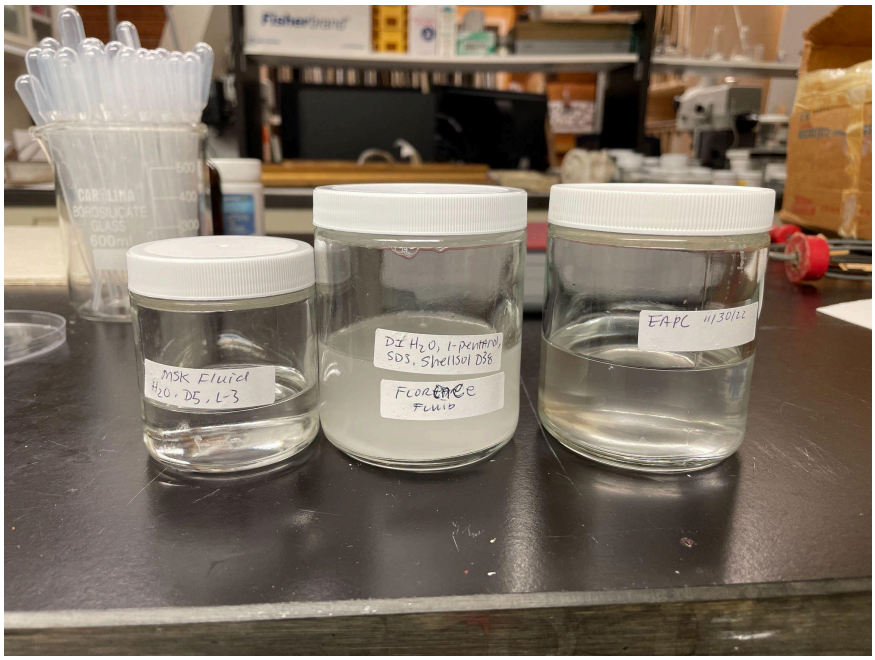
2. Michelle-Shannon-Kimi Fluid[4]
    a. Water *3.5mL*
    b. D5 *7.14mL*
    c. L-312 Surfactant *25mL*

Water:D5:L-312 Surfactant ratio - 10:20:70

Mixing procedure:

1. Measure deionized water
2. Add L-312 surfactant
3. Add D5
4. Let microemulsion sit for at least a day before use.

3. Florence Fluid[5]
    a. Water (continuous phase) – 85
    b. Surfactant (SDS) – 4
    c. 1-pentanol (co-surfactant) – 6
    d. Petroleum ether (dispersed phase) - 5 *sub Shellsol D38*



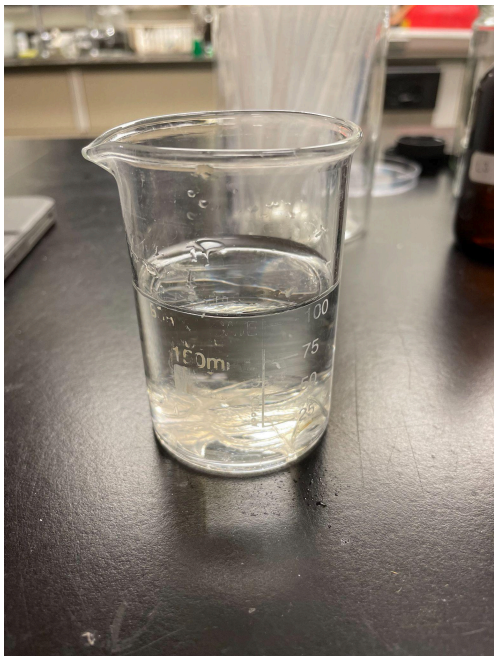
Mixing procedure:

1. Measure deionized water
2. Dissolve surfactant (SDS) in water.
3. Add 1-pentanol dropwise to the mixture.
4. Add Shellsol D38 dropwise to the mixture.
5. Let microemulsion sit overnight before use.

[4] New approaches to cleaning works of art on paper and photographs. Michelle Sullivan, Shannon Brogdon-Grantham, and Kimi Taira. 2014.

[5] https://journals.openedition.org/ceroart/1827

Pre-experiment testing



Soaking dried 10% agarose to see how much liquid it is going to take up and hold and want to be stable.

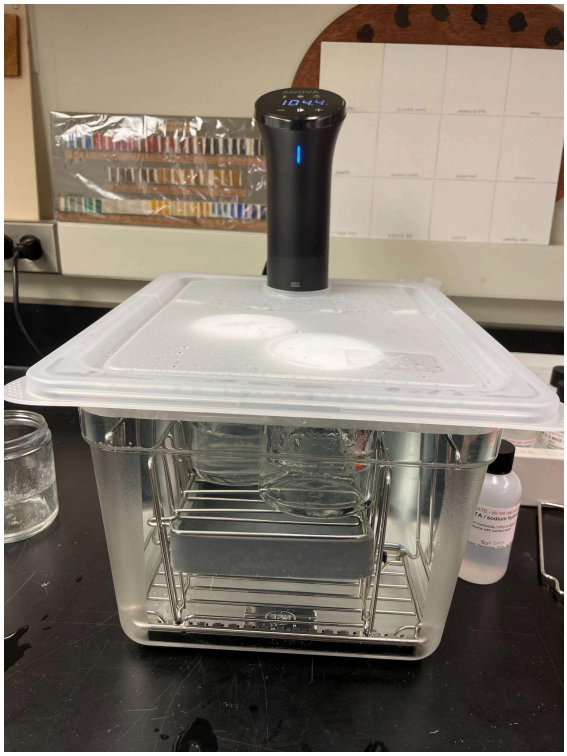
Experiment Procedure

1. Prepare PVA glass slides by applying two layers of the PVA solution and leave to dry and allow the ethanol to evaporate.
2. Prepare microemulsions.
3. Mix a 4% agarose gel using the microwave at 50% power. Stir occasionally.
4. Put agarose mixture in a water bath and lower the mixture temperature to 40C. Then quickly mix in microemulsion (try 10mL).
5. Cast the agarose gel and allow it to set.
6. Repeat steps 2-5 for 6%, 8% and 10% gels.

Raw Data

Figure 1: Temperature of Water Bath for Each Concentration of Gels

Agarose Concentration	**Temperature (C)**
4%	Liquid at 50
6%	Liquid at 50
8%	Liquid at 55
10%	Liquid at 60



Water bath to keep gels at temperature to extend their working time when mixing in EAPC

Figure 2: Boiling Point

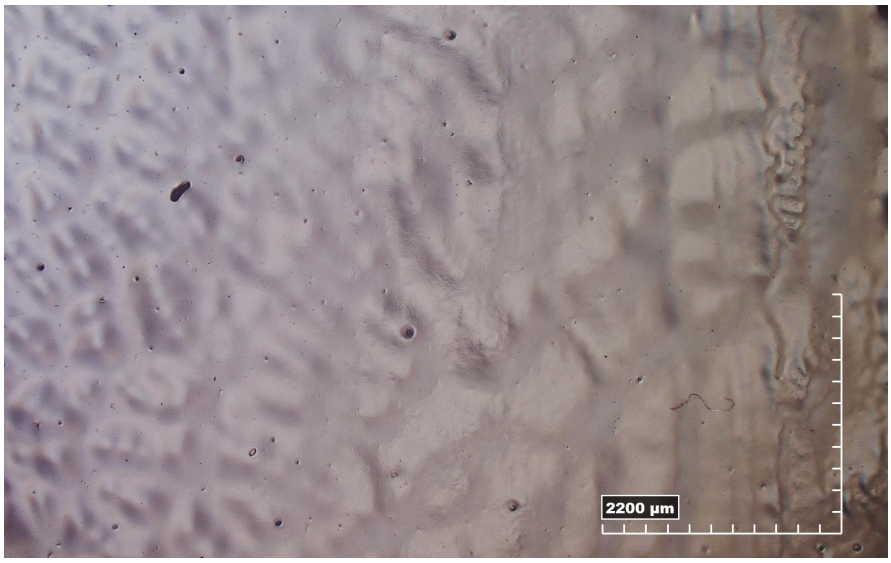
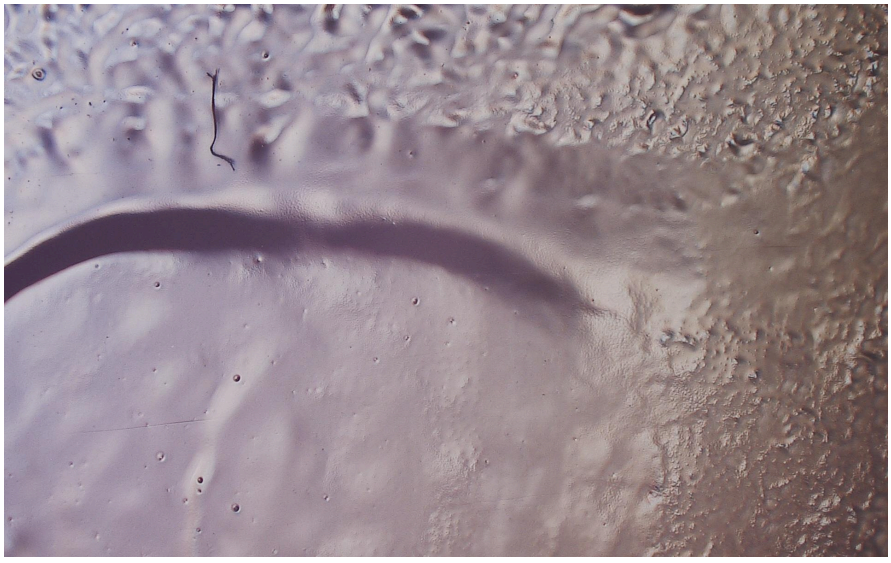
Material	**Temperature (C)**
Ethyl acetate	77
1-pentanol	138
SDS	204-207
D5	75
L-312 Surfactant	286
Shellsol D38	38
Propylene carbonate	242

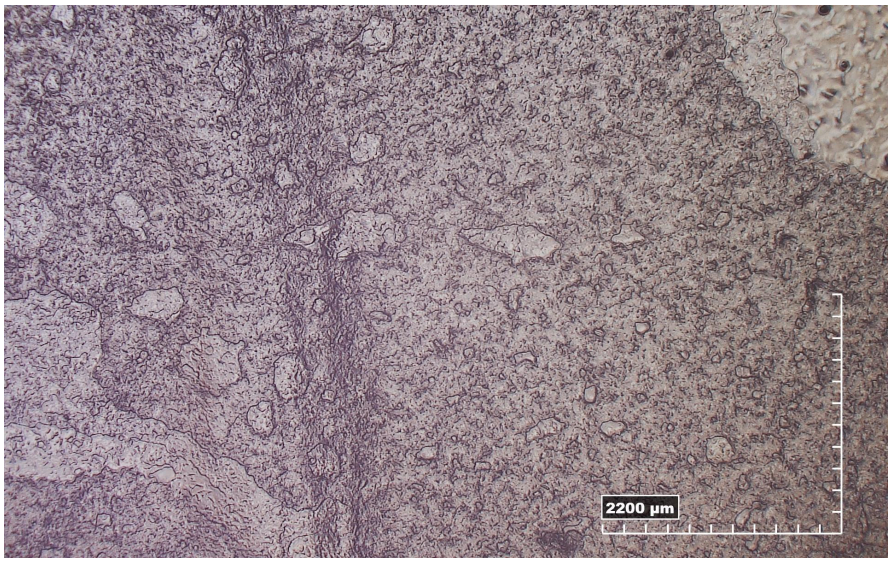
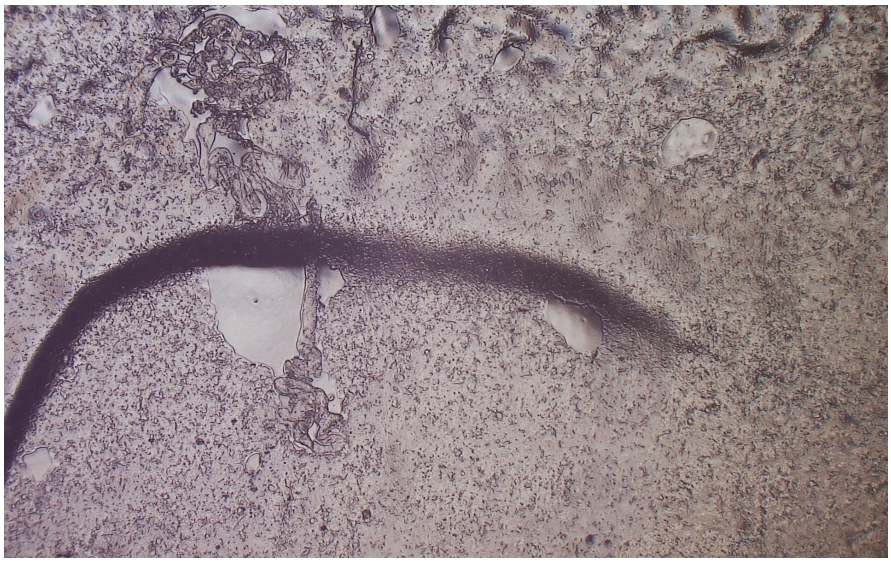
EAPC Gels

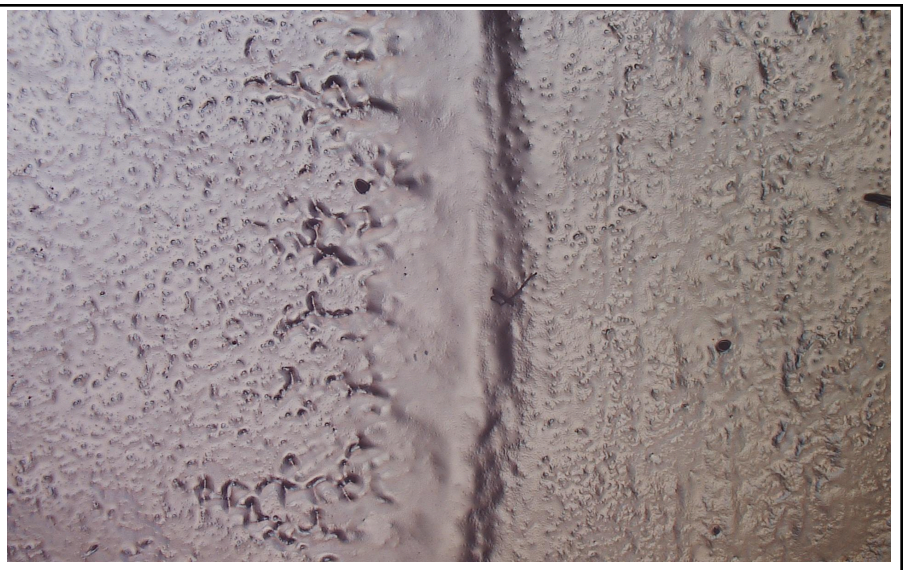
Agarose Concentration 100mL water	**Amount of EAPC included**	**Image of gel**
4%	25mL	
6%	15mL (could have maybe taken a little more?)	

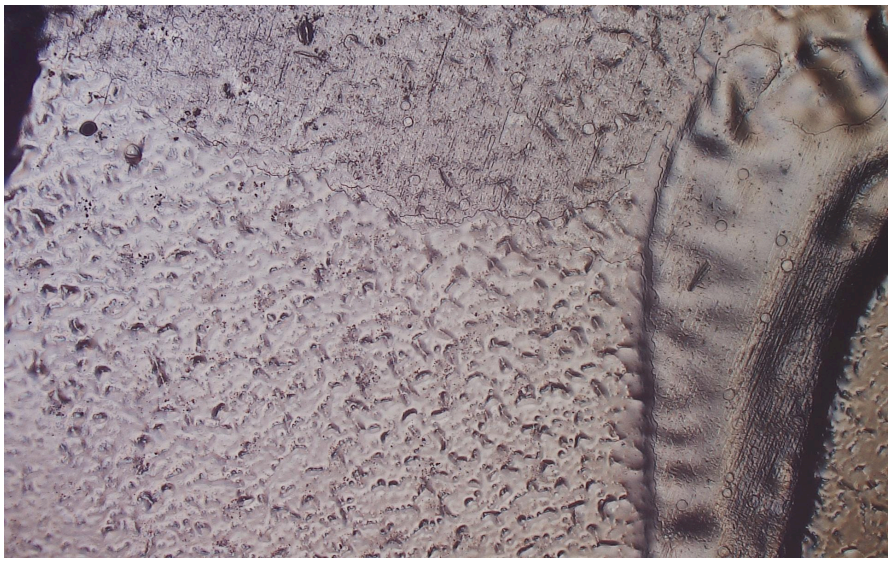
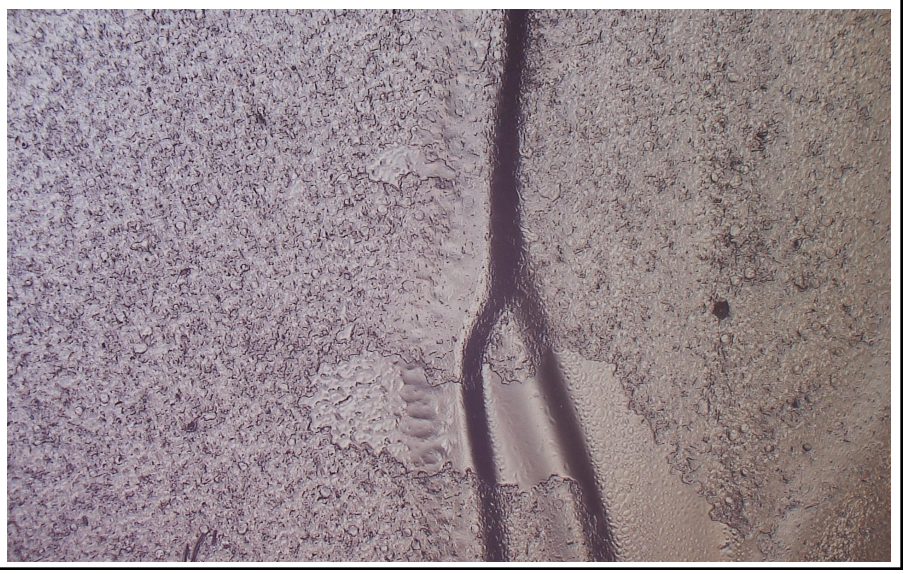
8%	10mL (maybe had to mix in less)	 A little lumpy after setting
10%	5mL	

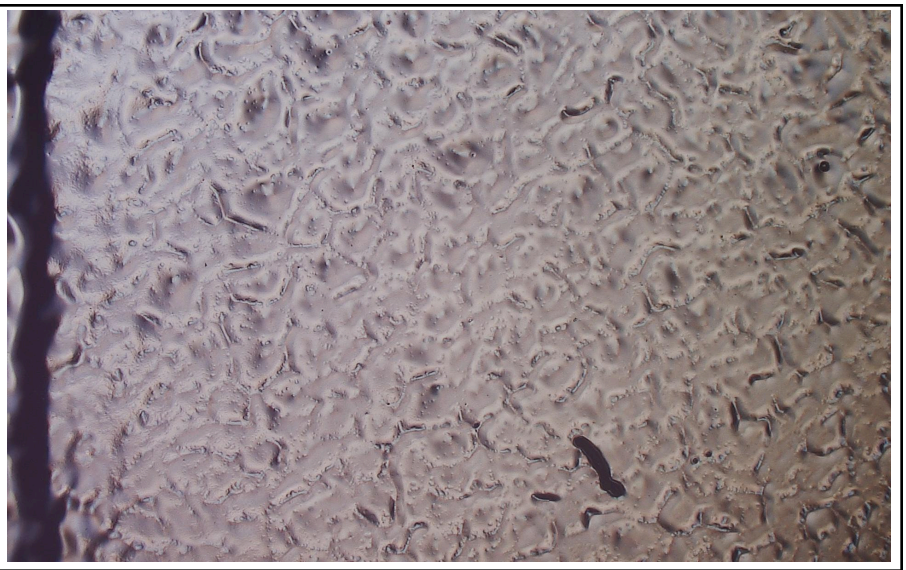
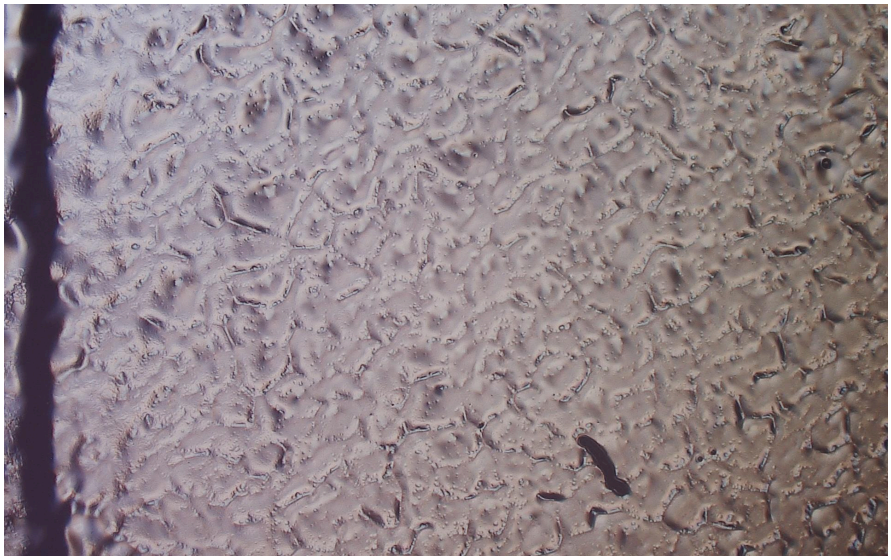
Figure 3: EAPC Fluid - waited 40 minutes

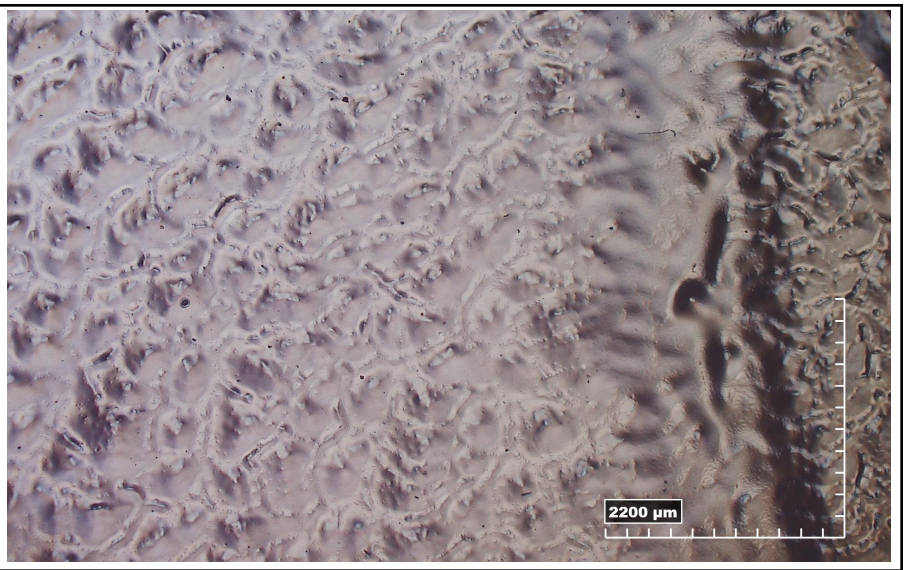
Agarose Concentration	**BT/AT**	**Photograph Hirox**
4%	BT (35x)	Test 1  Test 2 

	AT (35x)	Test 1  Test 2 
6%	BT (35x)	Test 1

		 Test 2 

	AT (35x)	Test 1  Test 2 

8%	BT (35x)	
	AT (35x)	
10%	BT	

	AT	

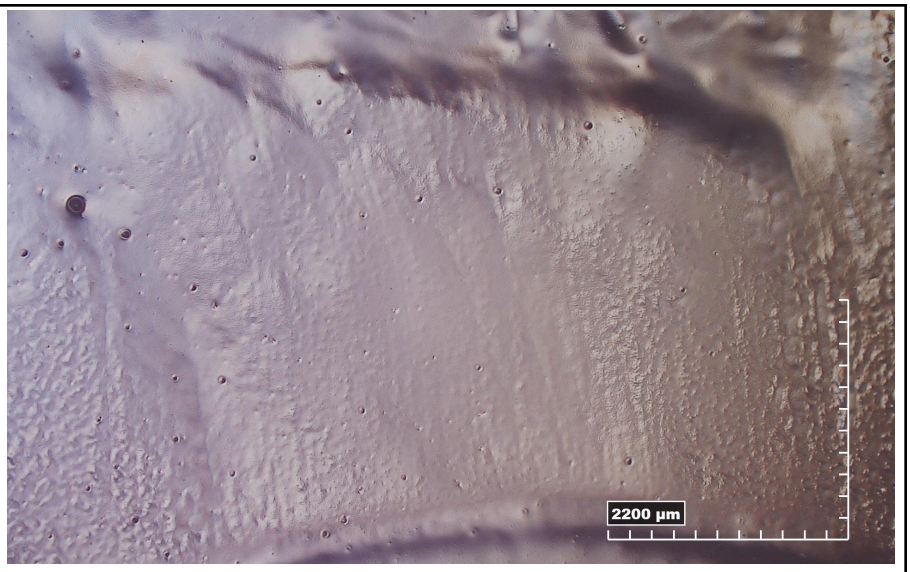
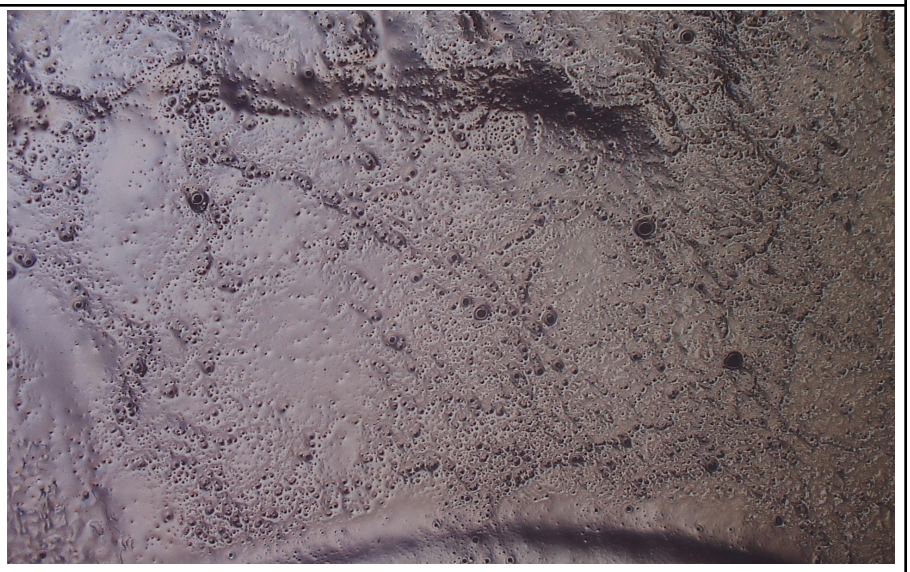
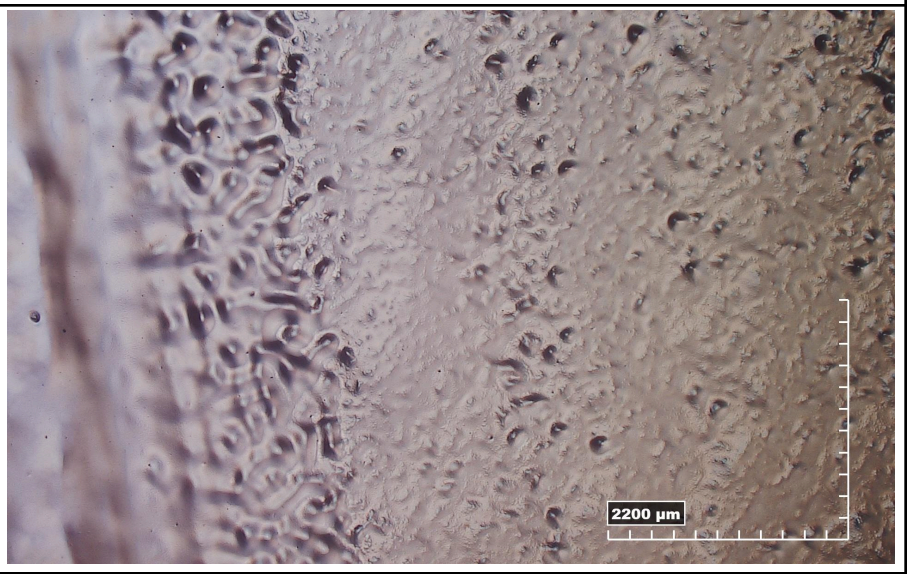
Michelle-Shannon-Kimi Fluid

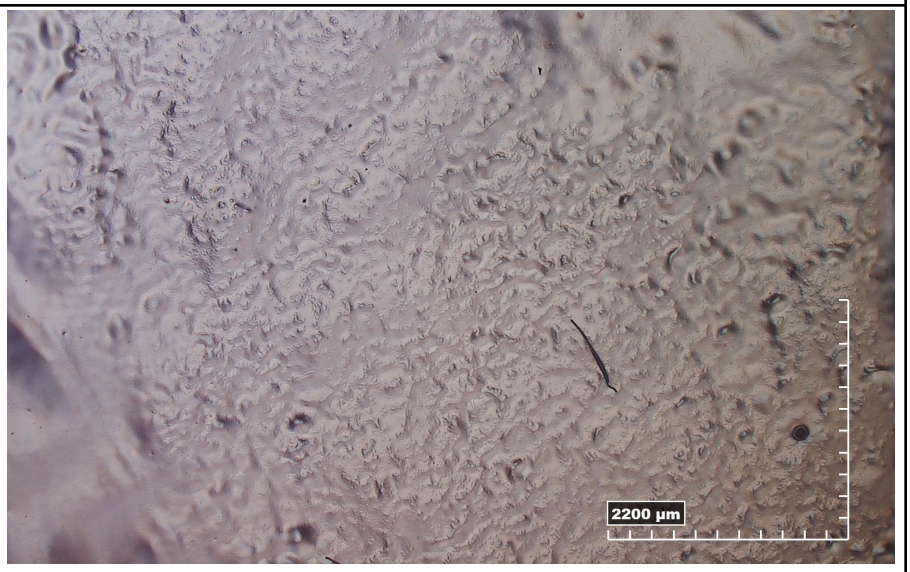
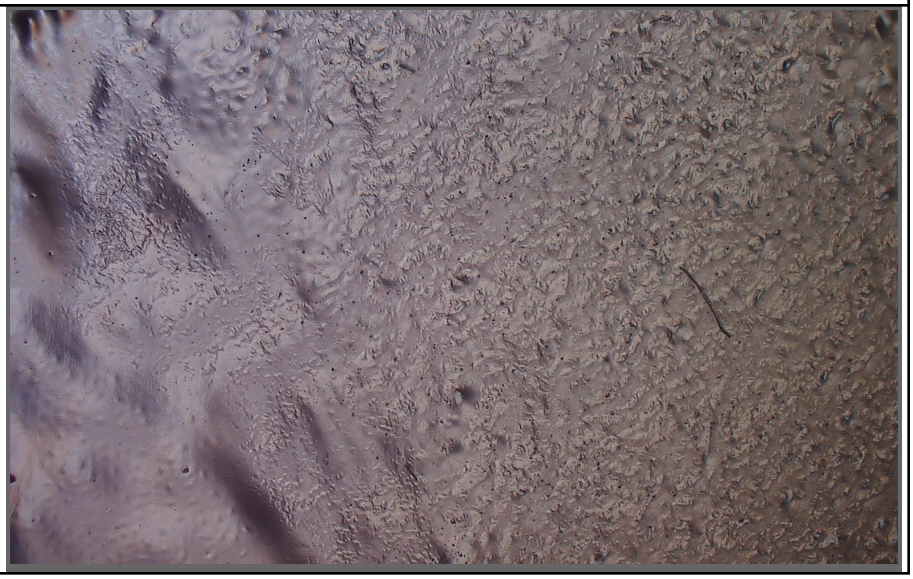
Agarose Concentration 50mL water	**Amount of microemulsion included**	**Image of gel**
4%	10mL	

6%	6mL	
8%	3mL	
10%	Did not make	Did not make

Figure 4: Michelle-Shannon-Kimi Fluid

Agarose Concentration	**BT/AT**	**Photographs**

4%	BT (35x)	
	AT (35x)	
6%	BT	

	AT	
8%	BT	
	AT	

10%	BT	
	AT	

Figure 5: Florence Fluid

Agarose Concentration	**BT/AT**	**Photographs**
4%	BT	
	AT	
6%	BT	
	AT	
8%	BT	
	AT	
10%	BT	
	AT	

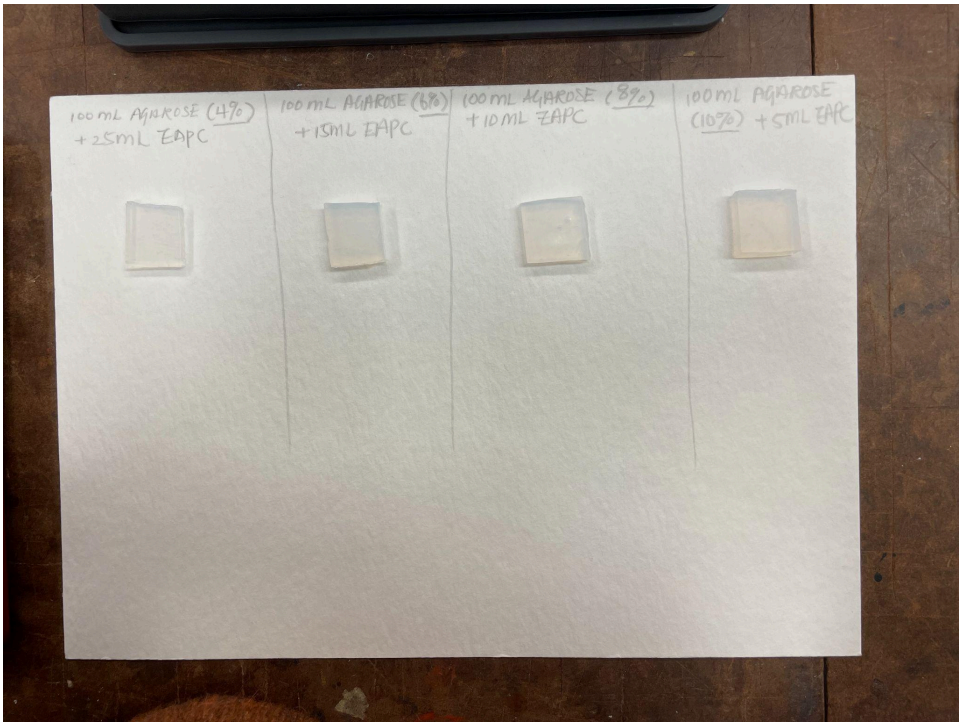
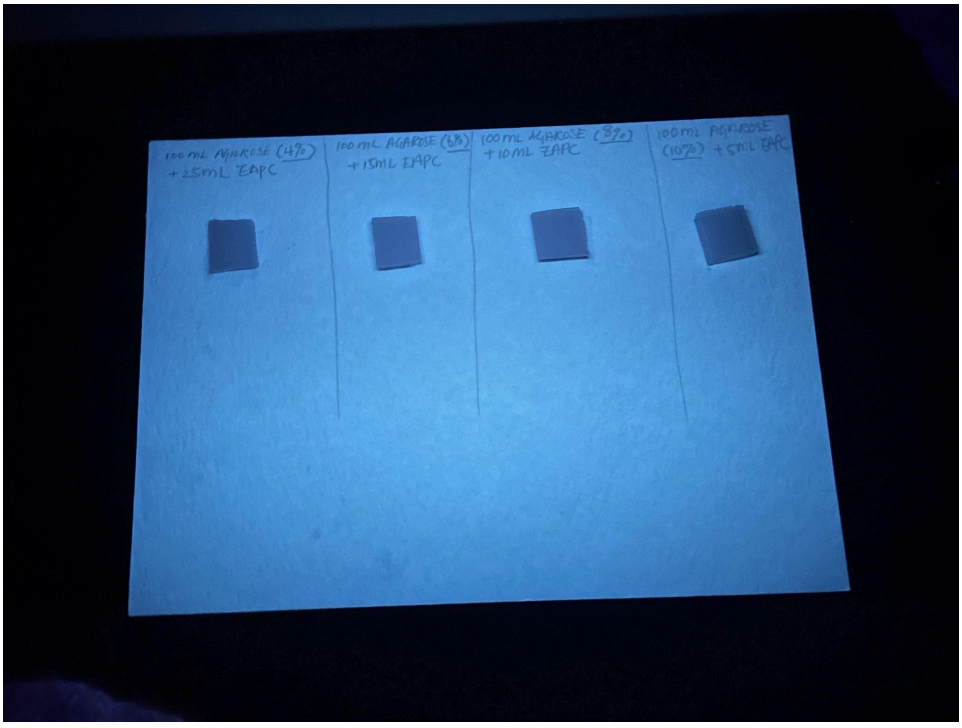
Notes and Observations

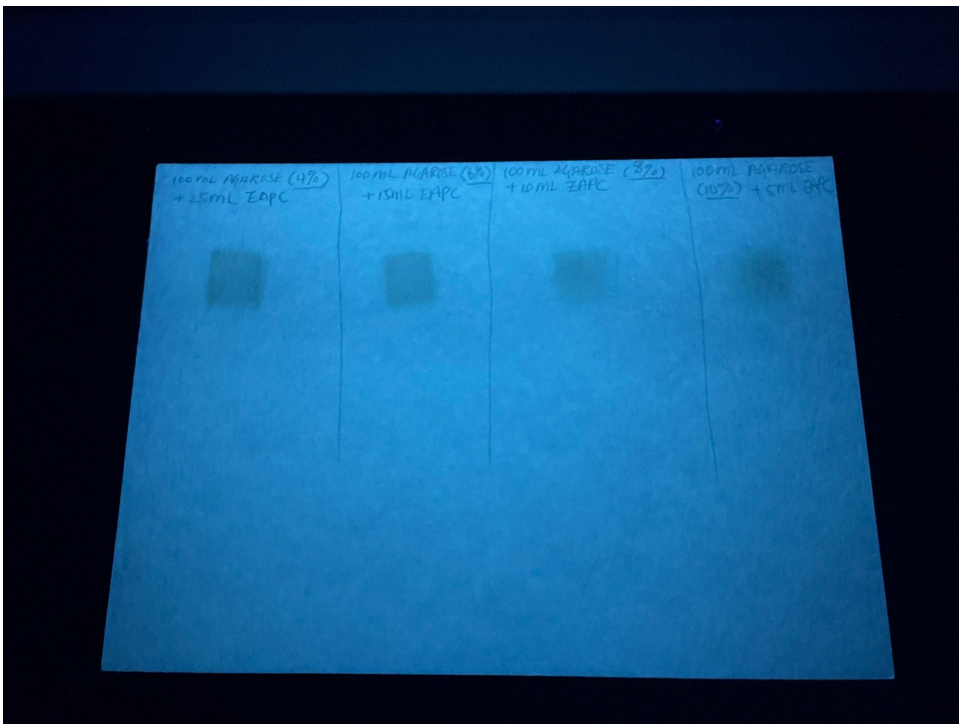
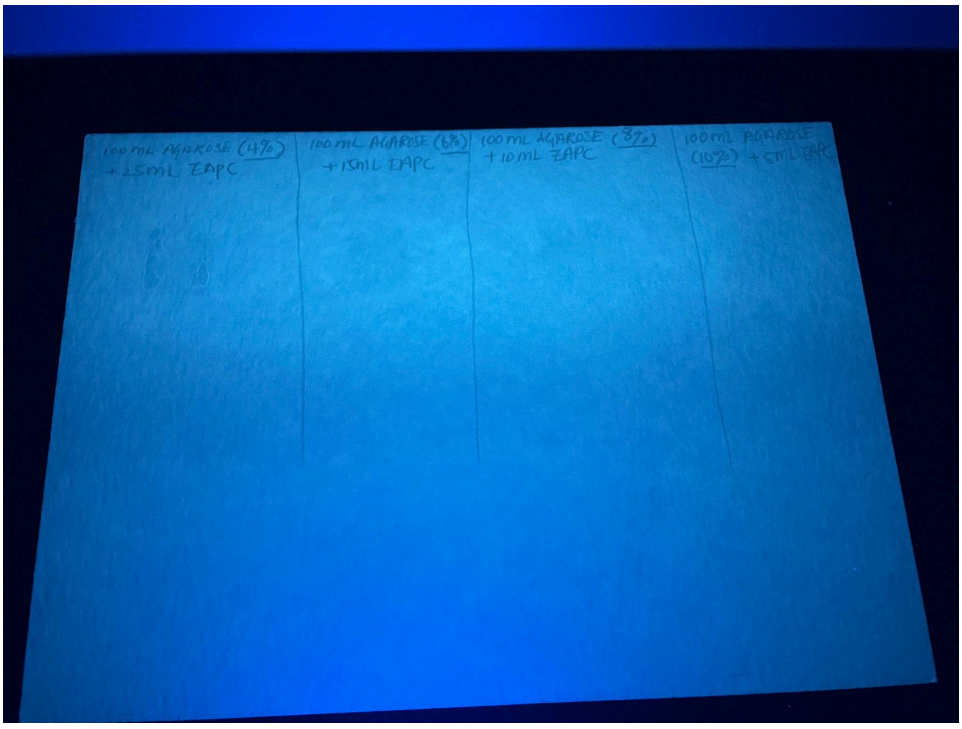
Agarose Concentration	**BT/AT**	**Notes**
4%	BT	
	AT	
6%	BT	
	AT	
8%	BT	
	AT	
10%	BT	
	AT	

Results

Part II: Observe the effect of different microemulsion gels (from Part I) on the stain removal of different Western papers in the Paper Lab Study Collection

EAPC Microemulsion rigid gels (UV), A Study of Potential Residue:

Normal Illumination	
Under UV	

UV of substrate after leaving gels for 1 hour	
UV of substrate after leaving substrate after 24 hours without reapplication	

<u>Part III: Observe the effect of different microemulsion gels on the stain removal on Xuan paper structures</u>

- Take cross sections to observe results