Attempt to Fabricate a Keratin/Cellulose Biocomposites from Arabidopsis Thaliana

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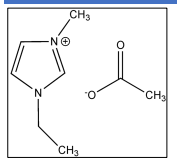
ABSTRACT

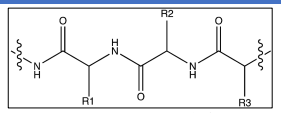
In this study, we report on the structural, thermal and morphological properties of cellulose-keratin biocomposites regenerated using ionic liquids and various coagulation agents. The cellulose was attempted to be extracted from a plant, Arabidopsis Thaliana. From there it could then be made into a biocomposite where characterizations test could be performed. Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), and X-Ray Scattering were used to characterize the physiochemical properties and morphology of the composites. The results suggest that keratin and cellulose structures can be manipulated during the formation of the biocomposite materials. Specifically, the beta sheet content in keratin increases with the increase of the ethanol solution concentration while the cellulose crystallinity increases with the increase of the hydrogen peroxide concentration during the coagulation process.

These results were obtained from a previous experiment on which this project was based. Due to the pandemic outbreak, this experiment proposed could not be completed, so the data on this poster is theoretically data for what should have occurred if the experiment was able to be completed

MATERIALS & METHODS



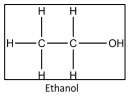
1-ethyl-3-methylimidazolium acetate (EMIMAc)



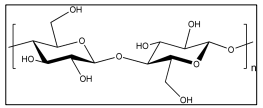
Keratin Azure

R= Cystine
Lysine
Methionine

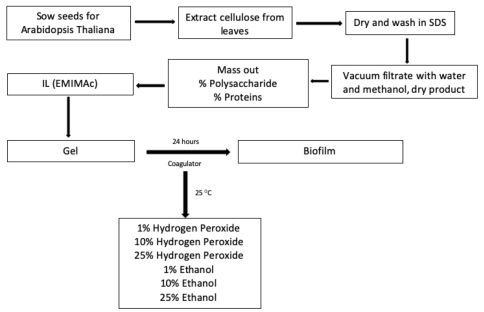
Hydrogen Peroxide



Ethanol

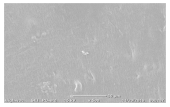


Avicel Cellulose

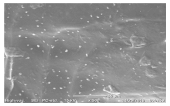


SEM IMAGES

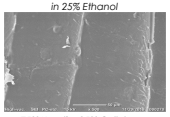
25% Keratin:75% Cellulose in 1% Ethanol



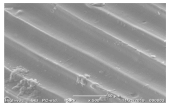
25% Keratin: 75% Cellulose in 25% Ethanol



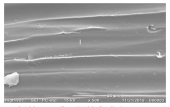
75% Keratin: 25% Cellulose in 1% Ethanol



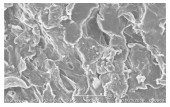
75% Keratin: 25% Cellulose in 25% Ethanol



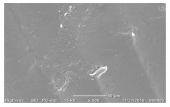
25% Keratin: 75% Cellulose in 1% Hydrogen Peroxide



25% Keratin: 75% Cellulose in 25% Hydrogen Peroxide



75% Keratin: 25% Cellulose in 1% Hydrogen Peroxide



75% Keratin: 25% Cellulose in 25% Hydrogen Peroxide

FTIR & BETA SHEET CALCULATIONS

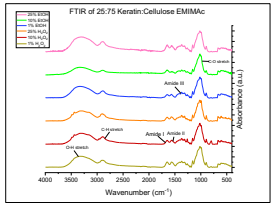


Figure 1. 25% Keratin: 75% Cellulose in varied coagulation agents

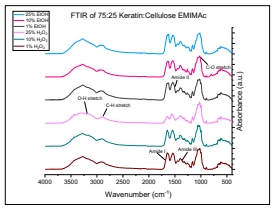


Figure 2. 75% Keratin: 25% Cellulose in varied coagulation agents

Table 1. Beta Sheet Calculations – Percentage of each secondary structure in all sample rations and coagulant baths

Sample Ratios	Coagulant Bath	Side Chains	Beta Sheets	Random Coils	Alpha Helices	Turns
25% Keratin: 75% Cellulose	1% EtOH	1.10%	29.61%	37.93%	13.87%	17.47%
	10% EtOH	0.47%	30.34%	39.33%	12.25%	15.99%
	25% EtOH	0.64%	27.07%	30.95%	4.43%	36.91%
	1% H_2O_2	0.49%	17.55%	28.41%	22.90%	30.95%
	10% H_2O_2	0.28%	15.35%	33.61%	16.35%	34.43%
	25% H_2O_2	0.045%	17.15%	33.46%	15.25%	34.09%
75% Keratin: 25% Cellulose	1% EtOH	4.00%	29.36%	30.63%	9.90%	26.12%
	10% EtOH	3.57%	32.47%	18.67%	23.39%	21.91%
	25% EtOH	3.76%	33.95%	21.91%	6.92%	33.35%
	1% H_2O_2	4.22%	31.29%	26.82%	17.28%	20.39%
	10% H_2O_2	1.18%	26.44%	41.93%	7.24%	25.62%
	25% H_2O_2	1.29%	25.74%	33.07%	20.54%	29.35%

X-RAY SCATTERING

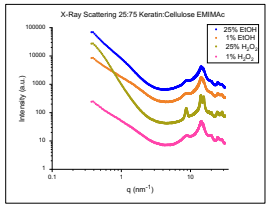


Figure 3. Keratin/Cellulose biocomposites using varied coagulation agents

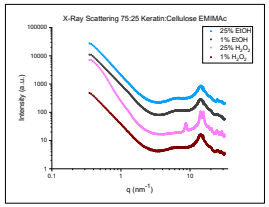


Figure 4. Keratin/Cellulose biocomposites using varied coagulation agents

TGA ANALYSIS

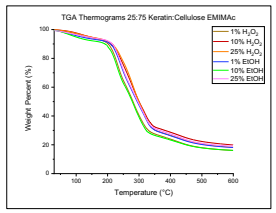


Figure 5. 25% Keratin: 75% Cellulose in varying baths

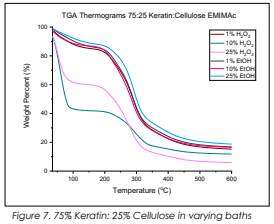


Figure 7. 75% Keratin: 25% Cellulose in varying baths

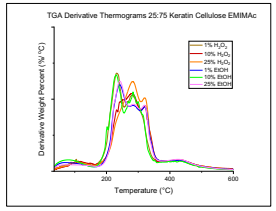


Figure 6. TGA Derivative Results of 25% Keratin: 75% Cellulose in varying baths

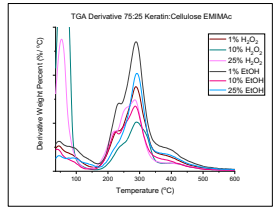


Figure 8. TGA Derivative Results of 75% Keratin: 25% Cellulose in varying baths

OBSERVATIONS

- In this research study it could be seen that as the concentration hydrogen peroxide increases the thermostability decreases. This could be seen at higher concentration of keratin and a lower concentration of cellulose.
- There is also an increase in beta sheets as the concentration of keratin increases in ethanol solutions
- The cellulose crystallinity increases with hydrogen peroxide concentration.
- Arabidopsis Thaliana took about 10 days to grow in a petri dish before leaves could be extracted
- Once fully grown, the leave size was very small which made it difficult to extract a large amount of cellulose
- Due to this, when attempting to make a film, it did not form as there was too little cellulose to mix with a proper amount of IL and keratin
- To try to solve this problem, a larger plant was in the process of being grown in soil

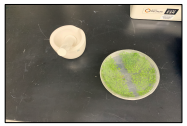


Image 1. Petri dish of Arabidopsis Thaliana and crucible

Image 2. Crucible of leaves, after pouring liquid nitrogen

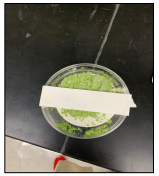


Image 3. Petri dish full of powder formed

Image 4. Power after drying in oven for 24 hours

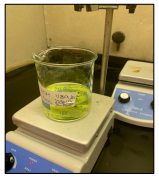


Image 5. Washing the dry powder in an SDS solution

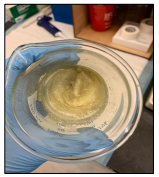


Image 6. Beaker of residue, had to be rewashed and then vacuum filtered

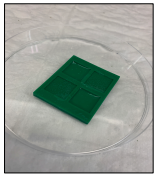


Image 7. Mold for biocomposite with IL and keratin/cellulose blend

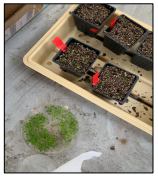


Image 8. Roots being extracted and placed into soil

DSC ANALYSIS

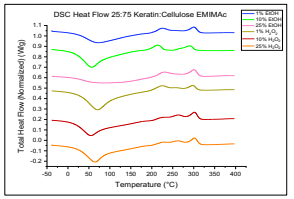


Figure 9. 25% Keratin: 75% Cellulose biocomposite films

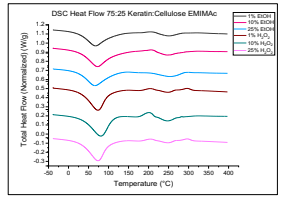


Figure 10. 75% Keratin: 25% Cellulose biocomposite films

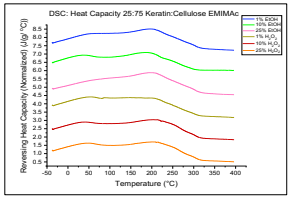


Figure 11. 25% Keratin: 75% Cellulose biocomposite films

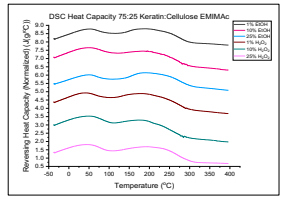


Figure 12. 75% Keratin: 25% Cellulose biocomposite films

ACKNOWLEDGEMENTS

I would like to thank Dr. David Salas-de la Cruz for assisting me throughout this project and for all his guidance throughout this semester. I would also like to thank Dr. Xingun Qi for assisting with the sowing of the seeds and plant growth process. Finally, I would like to thank my lab group and family for supporting me during this process.