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The Role of Plant Proteins in the Green Synthesis of Silver Nanoparticles

Katherine Trausch, Emanuel Waddell, Jeffrey Weimer and Anna Holmes
Department of Chemistry

Abstract

Brewing *Verbascum thapsus* leaves by irradiation from sunlight results in a "sun tea" that reduces silver ions to produce silver nanoparticles (AgNPs). Using two sets of sun teas with denatured and non-denatured proteins respectively, trials were conducted at the tea's natural pH 6.8 and teas buffered to pH 7.4, pH 8.2, and pH 9.0 at 24^{O}C (RT) and at an elevated temperature (ET) of 55^{O}C. All trials produced AgNPs. Characterization was conducted using dynamic light scattering (DLS), UV-Vis spectroscopy, and atomic force microscopy (AFM).

Introduction

Chemical AgNP synthesis uses sodium borohydride, classified by the Hazardous Material Information System with Health, Flammability and Physical Hazard ratings of 3, 3 and 2 respectively, on a scale of 0-4. Plants provide a green synthesis alternative. Biochemicals in plants that produce NPs include reducing sugars that reduce metal cations to base metal and proteins that act as potential capping agents. These proteins may prevent Ostwald ripening, keeping nascent NP size consistent for pharmaceutical use. The hardy plant *V. thapsus* used in this experiment grows on nearly every continent, making it largely available in green NP synthesis.

Living Plant Biochemistry – A Need to Standardize

Figure 1: Tea Normalization - Batch to Batch

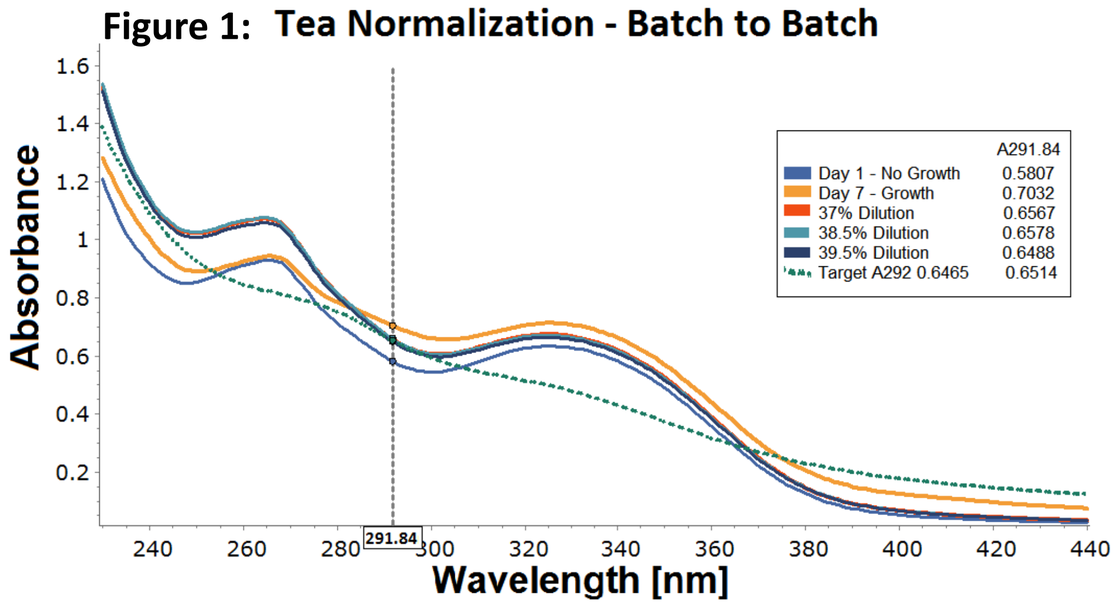
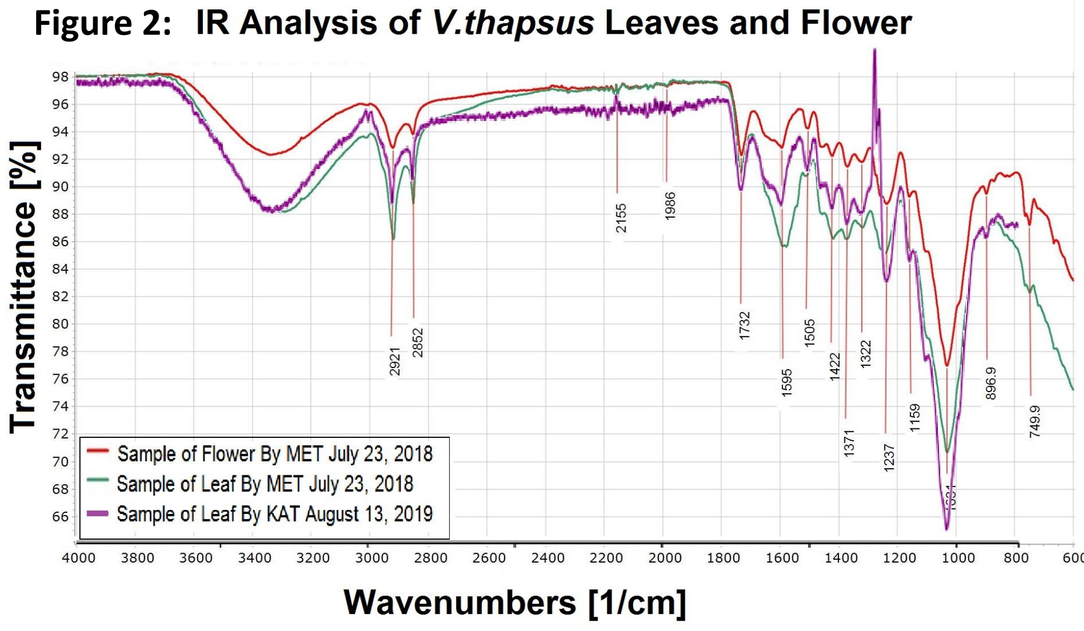


Figure 2: IR Analysis of *V.thapsus* Leaves and Flower



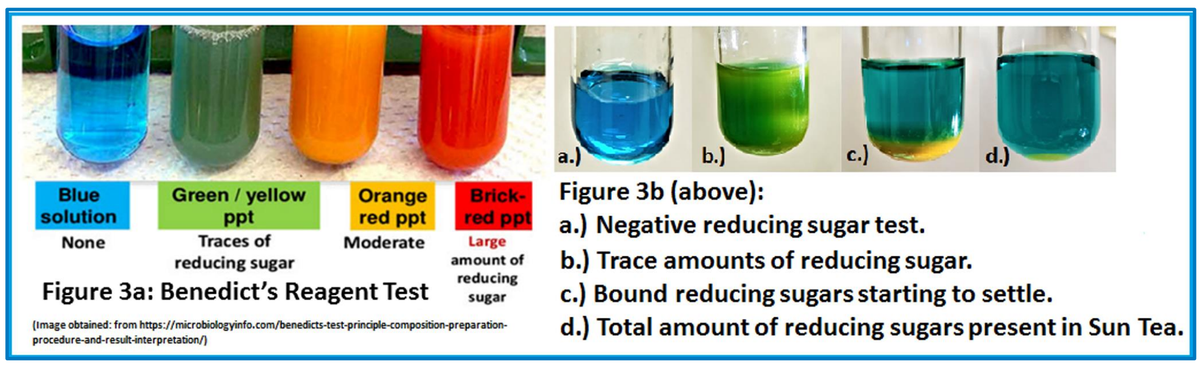


Figure 3a: Benedict's Reagent Test

(Image obtained: from https://microbiologyinfo.com/benedicts-test-principle-composition-preparation-procedure-and-result-interpretation/)

Figure 3b (above):
a.) Negative reducing sugar test.
b.) Trace amounts of reducing sugar.
c.) Bound reducing sugars starting to settle.
d.) Total amount of reducing sugars present in Sun Tea.

Data

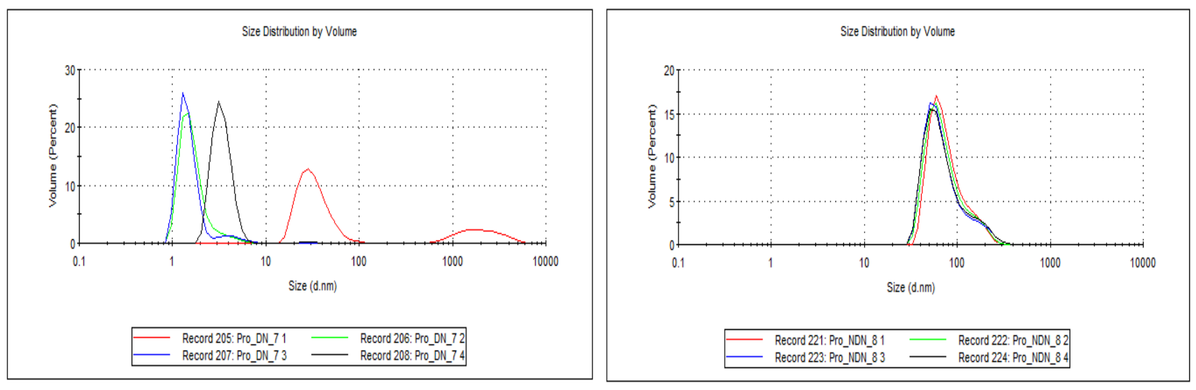


Figure 4: DLS

Sample	PDI	Peak 1 (d.nm)	% NPs by Volume	Peak 2 (d.nm)	% NPs by Volume	Peak 3 (d.nm)	% NPs by Volume
DN 7.4	0.645	33.51	77	2098	23	0	0
DN 8.2	0.456	10.81	99.1	4826	0.9	0	0
DN 9.0	0.5	5.506	100	0	0	0	0
NDN 7.4	0.211	75.06	39.7	217.3	14.3	4820	46
NDN 8.2	0.166	81.59	100	0	0	0	0
NDN 9.0	0.194	86.11	100	0	0	0	0

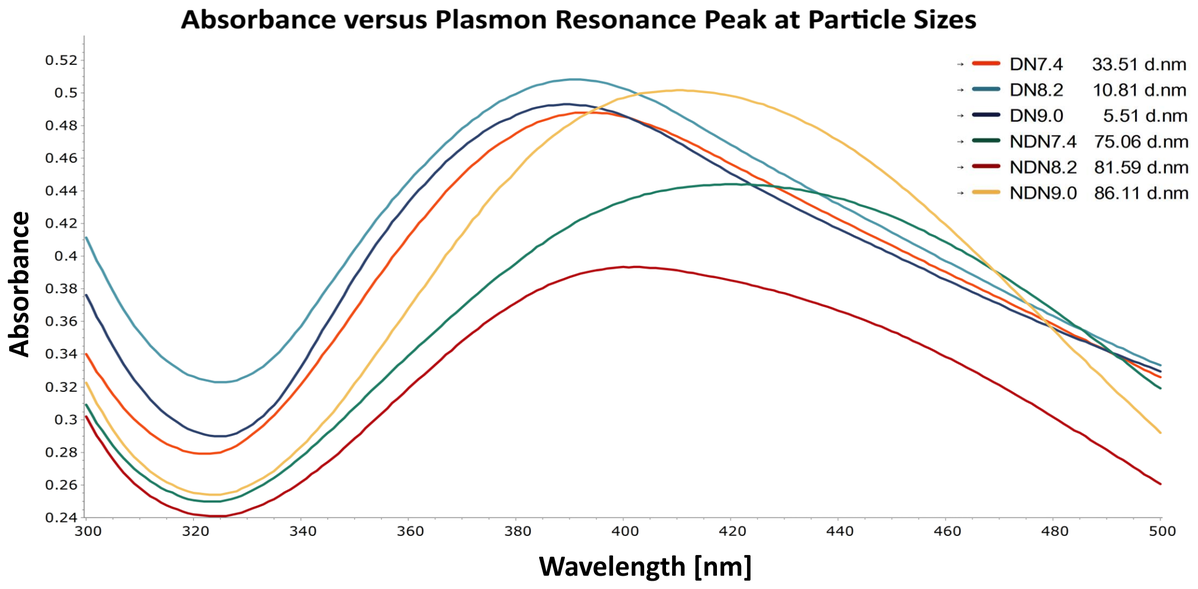


Figure 5: Effect of AgNP particle size on absorbance peaks in the UV-visible spectrum.

AFM

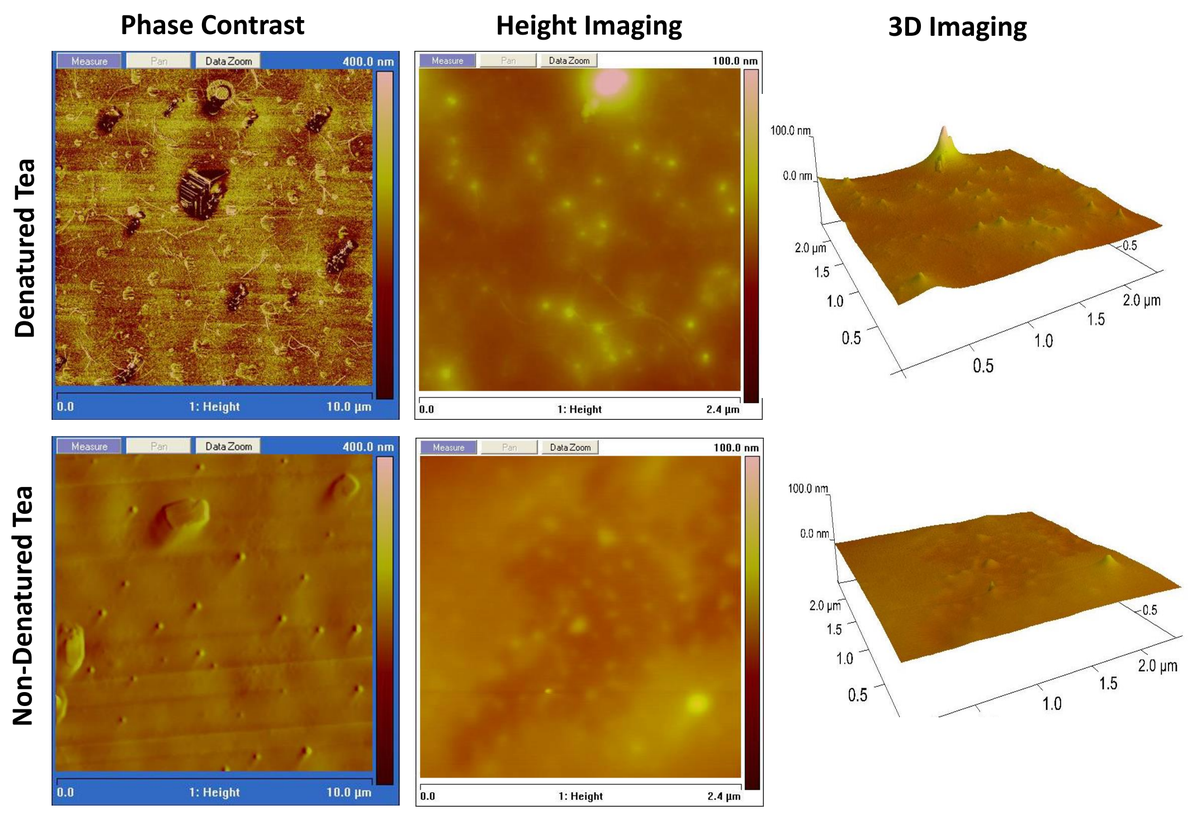


Figure 6: Comparison of phase contrast, height, and 3D images showing presumed protein "snow blanket" covering.

Conclusions

Non-denatured sun tea synthesizes AgNPs with low polydispersity and coats them with an apparent protein layer that increases particle size. Denatured sun tea synthesizes NPs at a desired size but with higher polydispersity among the nuclei. Higher pH buffers provide lower polydispersity in both teas and the desired size in the denatured tea. Low quantities of reducing sugars in the teas limit the contribution of these sugars to cation reduction.

Citations

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Acknowledgements

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