Formulation and Development of Graphene-Based Printable Sensors

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Background

The field of printable electronics and sensors is one that has experienced growing interest within the past decades. It is predicted that the world will require 45 trillion sensors by the late 2020s [1] and that printed electronics will hold a share in the $74 billion combined market of printed, organic, and flexible electronics by 2030 [2]. Of the inorganic materials being researched for use in printed electronics, graphene is of specific interest due to its high current density, chemical inertness, high thermal conductivity, and optical transmittance [4].

Project Objectives

This project is focused on the formulation and development of a graphene-based ink that is suitable for a printable sensor and exhibits the characteristics of being of high electrical conductivity, easy manufacturability, and printable through an inkjet-based printer. To do this, an ink formula developed by Parvez's team [4] and the graphene synthetization methods mentioned in Secor [5] and Tyurnina's [6] works will be combined and modified to develop a new ink of high electrical conductivity with optimal surface tension, viscosity, and flake characteristics for inkjet printing.

Ink Formulation Process

A dispersion of graphite flakes mixed in deionized water was placed in a sonication bath operating at 80 Watts and 40 kHz frequency for 180-minutes. This sample was then vacuum filtrated through 0.2 µm filter paper to remove large graphene flakes. Propylene Glycol, Triton X-100, and Xanthan Gum were mixed into the filtered sample to act as binders and additives that alter the rheology of the sample.

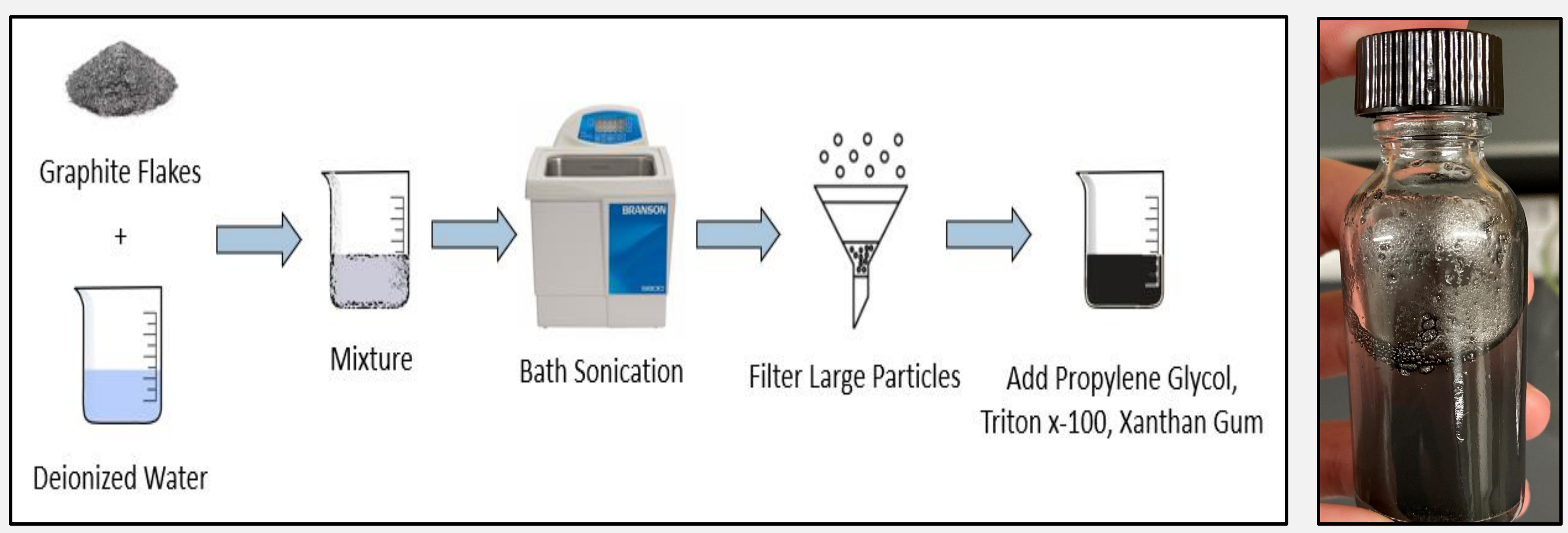

Figure 1: Schematic of the ink formulation process and a photograph of the sonicated sample.

Ink Characterization

The formulated ink was primarily characterized by its dynamic viscosity as a function of shear rate; particle height and lateral size statistical quantities from an AFM sample of 75 flakes; and the conductivity of three samples prepared with different ink volumes and drying methods.

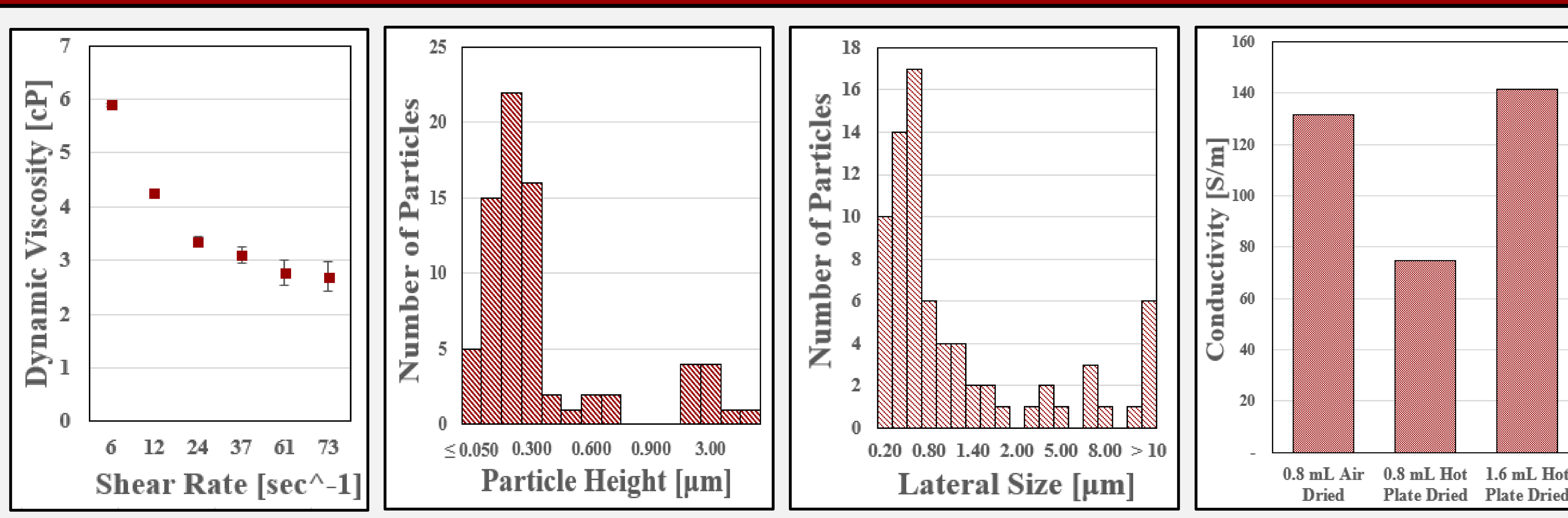

Figure 2: Results of the viscosity, particle height, lateral size, and conductivity tests of the formulated ink.

Theoretical Printability

Table 1: Tabulated Z values for different dynamic viscosities and characteristic lengths (nozzle diameter). Green cells represent theoretically printable; yellow represents possibly printable; and red represents unlikely to be printable.

	Z Value					
	Characteristic Length [µm]					
Viscosity [cP]	20	30	40	50	60	70
5.90	4.82	5.90	6.81	7.61	8.34	9.01
4.26	6.67	8.17	9.43	10.55	11.55	12.48
3.36	8.46	10.36	11.96	13.37	14.65	15.82
3.10	9.17	11.23	12.96	14.49	15.88	17.15
2.76	10.30	12.61	14.56	16.28	17.83	19.26
2.70	10.52	12.89	14.88	16.64	18.23	19.69

References

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