Name(s)

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Project Number

S0608

Project Title

A Smartphone-based Low Cost, Portable, and Accurate Optical Tensiometer to Determine Cleaning Power of Soap

Abstract

Objectives

I used a smartphone to build a low cost, but highly accurate instrument to measure contact angle of soapy water with a surface.

Methods

A compact, low cost optical tensiometer was built by using smartphones that have high quality camera, level sensors, angle measure apps and image manipulation apps. These capabilities were combined with a high quality macro lens, a stage integrated with the cover of the macro lens, a bright but low power LED flash and a 3-D printed light box to build our instrument. Three liquids with known surface energy, and DI water were used to calibrate the instrument. Three different soaps were tested to determine their cleaning power as a function of concentration.

Results

(1) Developed instrument was compact, with (a) precision, as measured by std deviation, of 1.8 degrees, (b) accuracy of +/- 2%, and (c) a total cost of $ 150. Commercial instrument is bulky, with std deviation of 1 degree, accuracy of +/- 1%, and a cost of $ 14000. The precision and accuracy of developed instrument are acceptable, cost is almost two orders of magnitude lower.

(2) Using this instrument, we tested the effect of soap in lowering surface tension of water, and observed:
(a)Reduction of surface tension depends on the type of water.
(b)Same soap from Dollar Tree ($1) performs as well as that from Ralph's($2).
(c)Dawn soap performed better than Palmolive and Ajax for local tap water. Dawn needed only 0.25% soap to reduce surface tension to its lowest value, whereas Ajax needed about four times as much.

Conclusions

Our project shows that for a given tap water, one can choose the right soap and the minimum amount that cleans effectively, using a low cost instrument based on widely available smartphones. Wide availability and ease of operation of this instrument will increase probability of reusing water by minimizing the use of soap. We believe that smartphones provide a combination of computing power, and a suite of built-in sensors that can be exploited to enable many other low-cost, highly effective sensors and instruments for household use.

Summary Statement

Fabricated a portable contact angle measurement instrument with similar accuracy and precision as a commercially available instrument, but with two orders of magnitude lower cost.

Help Received

I acknowledge Dr. Rahul Ganguli for help with understanding the surface science. All experiments were performed at home.