Photoelectric sensor setup and characterization for general interface detection in laboratory scale liquid-liquid extraction processes

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Introduction

Liquid-liquid extraction involves adding a solvent in a mixture to extract a substance of interest, and is widely used in different processes, including battery chemical synthesis.

The solvent and the rest of the liquid are immiscible, thus they separate after some time.

Automatic extraction devices aim to detect the liquid-liquid interface between the remaining liquids, but are often tailored to specific industrial processes, which are either of a too big scale or a too small scale.

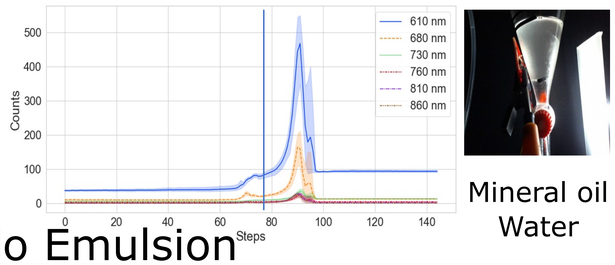
A sensor for detecting different interfaces with varying optical features at laboratory scale, attached to a separatory funnel, is investigated.

Sensor Setup

A photoelectric sensor array (Sparkfun Triad Spectroscopy) is used to detect the interface. A normal separatory funnel is illuminated by a diffused light source (Diffused 450-700nm LEDs) from the opposite side. The optical properties of the liquid and of the interface determine the light that is cast in the sensor array.

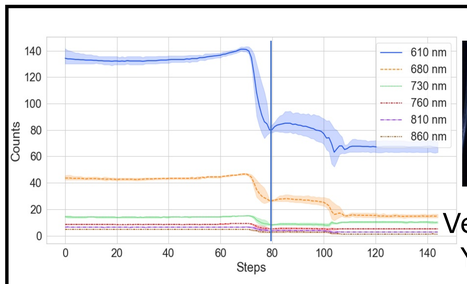
Characterization

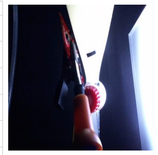
Different mixtures of oil and water, simulating organic and watery phases, are used to test the sensor capabilities, the main limitation of the sensor arrangement comes when the two liquids are very similar optically and with almost no emulsion in between (Upper left). In this case the sensor must rely on the interface reflection. Emulsive interfaces, which are difficult to spot with cameras [1], cast a shadow in the sensor, making them easier to spot. Measurements are recorded as the separated liquids are drained with a dosing pump at a rate of approximately 1ml per step.



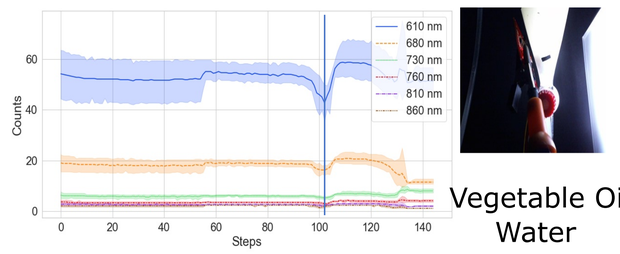
Mineral oil
Water

No Emulsion

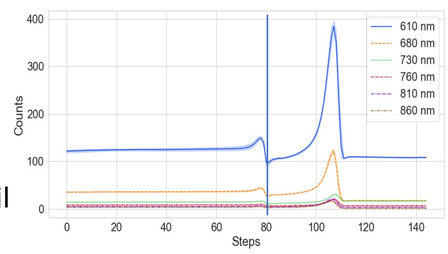


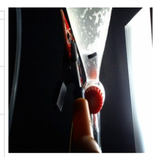


Vegetable Oil
Yellow ink
Water



Vegetable Oil
Water

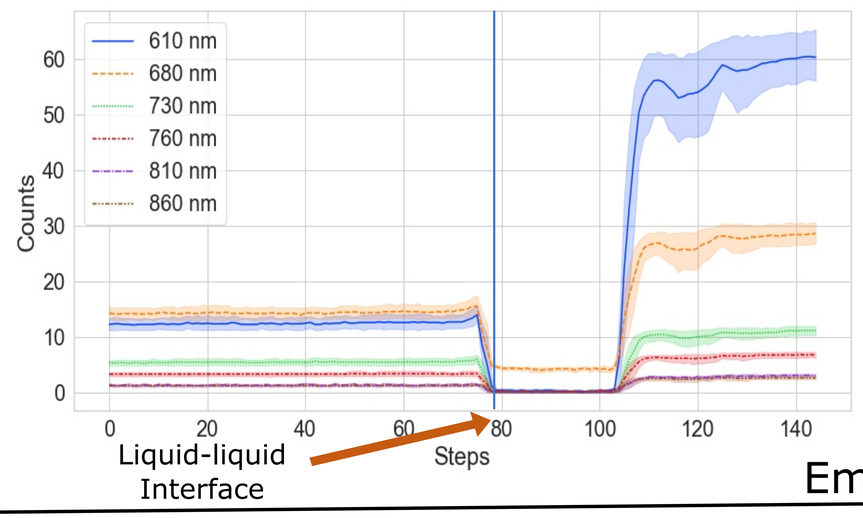




Mineral oil
Water

Graphs in process of publication

Emulsion



Emulsion

Dataset

The measures portrayed, including substance composition data, can be found in the following repository.

Conclusion

A photoelectric sensor setup for detecting liquid-liquid interfaces in liquid-liquid extraction processes, capable of detecting different interfaces and aimed to be used in battery chemical synthesis, is described.

Liquids with similar optical features limit the sensor performance.

Emulsive interfaces, which are difficult to detect with cameras, cast a shadow in the sensor, making them easier to spot.

The sensor setup can be adapted to different machines and tools.

References

1. Eppel, S., & Kachman, T. (2014). Computer vision-based recognition of liquid surfaces and phase boundaries in transparent vessels, with emphasis on chemistry applications. 1–36. http://arxiv.org/abs/1404.7174

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