Fluorescence Spectroscopy for Fast and Simple Detection and Counting of Viruses in Water

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Motivation

Globally, more than 2 million deaths and 4 billion waterborne disease cases annually can be attributed to the use of microbial contaminated water sources [1]. Household water treatment and safe storage (HWTSS) systems have shown to improve the microbial water quality but are less effective in the removal of waterborne viruses. Viruses are very small particles (e.g. 20-100 nm), the infective dose can be very low (~10-100 particles), they are transmitted via the fecal-oral route and are persistent in aquatic environments for extended periods of time.

For the removal of pathogens from drinking water, membrane filtration is a promising technique. Membranes are able to retain very small particles, which may aid in producing microbial safe drinking water. To test, develop and optimize such membrane filters in a limited time, a fast and simple method to quantify virus reduction is mandatory. Combining our knowledge of virology and fluorescence spectroscopy and microscopy are used to develop in quick and easy method to quantify viruses for the development of membranes.

Technological challenge

Currently applied methods to test the efficiency of membrane filters for reduction of waterborne viruses are mostly based on cell culture methods. The proposed fluorescence based assay will be able to detect and count the viruses with high sensitivity. It will be able to quantify the virus retention and inactivation efficiency of membrane filters within few seconds.

The bio-assays [2,4] are accepted as the gold standard [3], however, these assays require specialized laboratory facilities, are complex and rely on a high degree of expertise. The complexity and time required for these assays make them not well suited for membrane development, optimization and installations purposes, which require fast, simple and robust tests for virus retention.

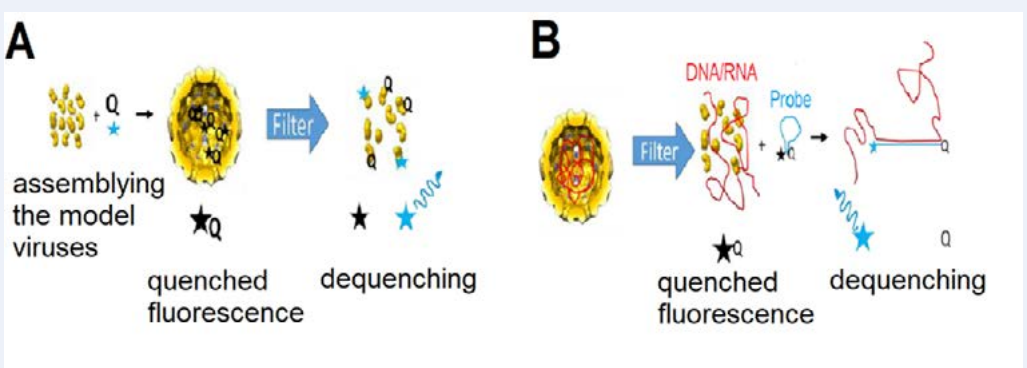

Fig 1. (A) Capsid disassembly as a readout for virus inactivation, (B) RNA/DNA release as readout for virus inactivation and identification

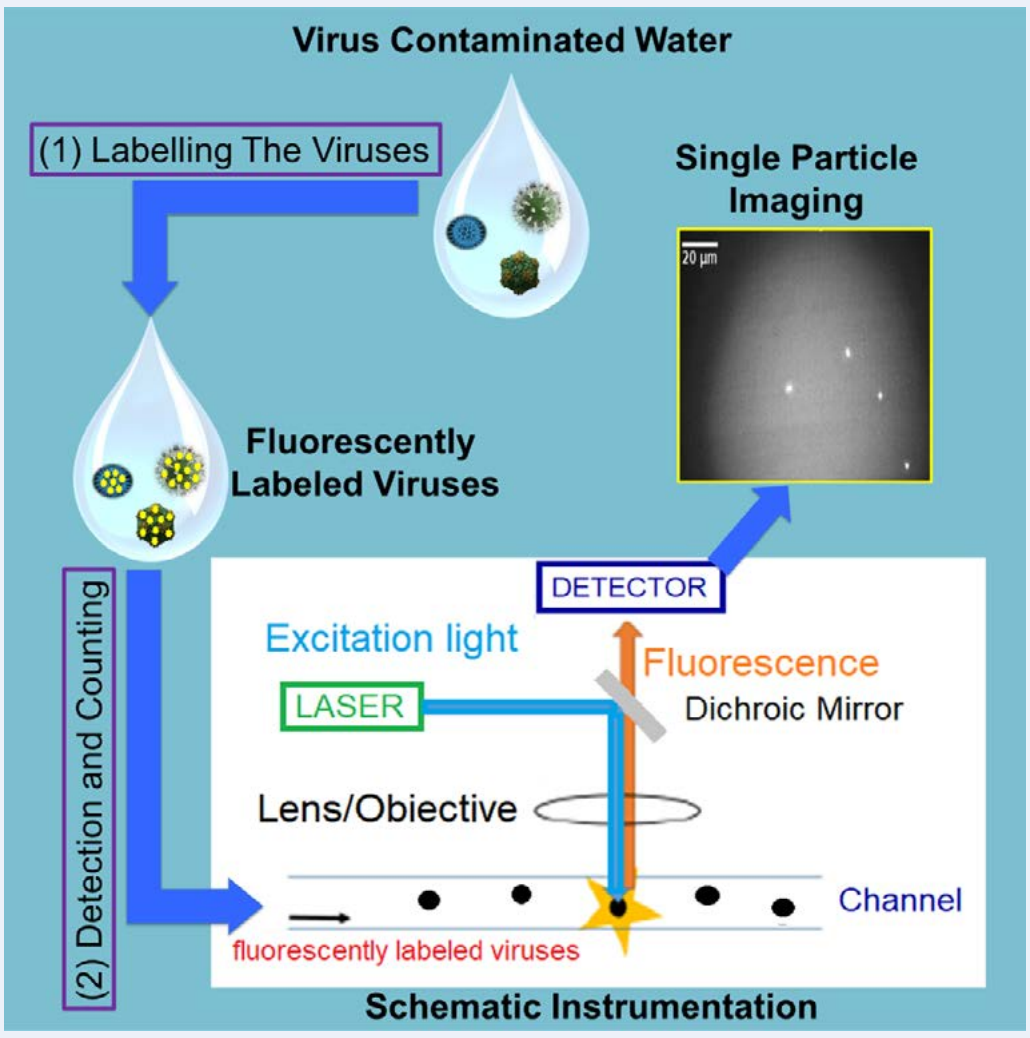

Fig 2. Flow-cycle of Detection and Counting of Fluorescently Labeled Viruses in Water

Research goals

- Develop an instrument that can detect the necessary low numbers of labeled viruses using fluorescence spectroscopy and microfluidics (Fig. 2)
- Use fluorescently labeled viruses to study retention of membrane filters and benchmarking the proposed fluorescent assay against the existing virus detection methods
- Discriminate between mixtures of different labeled viruses
- Study the mechanism of virus inactivation due to virus capsid disruption or disassembly (Fig. 1A)
- Identify native viruses in the filtrate based on DNA / RNA identification (Fig. 1B)

References

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