Proposed DEP-Raman device for simultaneous trapping and identification of bacteria

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Typical bacterial identification methods can take several days to complete. In order to reduce analysis time, researchers have used a variety of methods for bacterial identification such as polymerase chain reaction, Raman spectroscopy, and fluorescent in situ hybridization. Although these methods have successfully decreased bacterial analysis time from days to a matter of hours, they require a pure sample or a way to label bacteria with fluorescent tags, antibiotics, or primers. Pure samples require a number of purification steps that lead to loss of sample, and appropriate fluorescently-marked antibodies increase costs and wasted materials due to the broad range of bacteria strains that cause infections and disease. As such, label-free isolation and identification methods like dielectrophoresis (DEP) and Raman spectroscopy are appealing to reduce costs and increase simplicity and efficiency. DEP is the motion caused in a particle as it passes through a non-uniform electric field and can be used to sort, isolate, and trap particles. This study successfully demonstrates simultaneous trapping and identification of 3.3 μm polystyrene spheres using DEP and Raman spectroscopy. It is proposed that the DEP-Raman device can be developed to sort and identify bacteria from a mixed sample in a matter of minutes leading to prompt and accurate treatment.

**Introduction**

Dielectrophoresis (DEP) is becoming a more popular means for sorting of biological samples as it is a label-free technique. The technique requires a non-uniform electric field, which causes motion in neutral particles as illustrated in Figure 1. DEP can be used to isolate bacteria in order for another technique such as Raman spectroscopy to identify bacteria. Figure 2 illustrates the process of Raman scattering, resulting in spectra that can be used as a means to identify samples.

**Design**

![Diagram of DEP-Raman device](image)

- 3D printed plate
- PDMS layer to seal device
- Fused silica microfluidic plate
- Viewing port

Figure 3: Representation of a DEP device composed of fused silica, PDMS, and 3D printed materials. Layers are held together with 8-32 screws and bolts [2].

**Results**

![Image of DEP device under operation](image)

Figure 6: Image of the DEP device under operation (350 V<sub>AC</sub>, 100 Hz, 5 μL/hr) trapping 3.3 μm spheres. Square pillars are 100 μm by 100 μm. Upon trapping, spheres were analyzed using Raman spectroscopy [2].

![Image of Raman spectra](image)

Figure 7: Image of Raman spectra collected from 3.3 μm polystyrene spheres (PSS) trapped in the DEP device (black), PSS on a quartz coverslip (blue), PDMS (green), and quartz coverslip without PSS (red) [2]. Raman spectra were collected using 785 nm laser, 14 mW power, 25 second acquisition, and one accumulation.

**Discussion**

This study successfully demonstrated the simultaneous isolation and identification of 3.3 μm polystyrene spheres in a DEP-Raman device, indicating the potential of trapping and identifying bacteria from clinical samples. Future work is aimed at separating and identifying a mixed sample of debris and bacteria to mimic real samples. The separation will be done by using a series of pillar arrays each designed to trap the specific particles/cells for Raman analysis.

**References**