

# Dielectrophoresis affects particle motion in electrostatic traveling waves: a potential application for lunar soil beneficiation

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## Outline

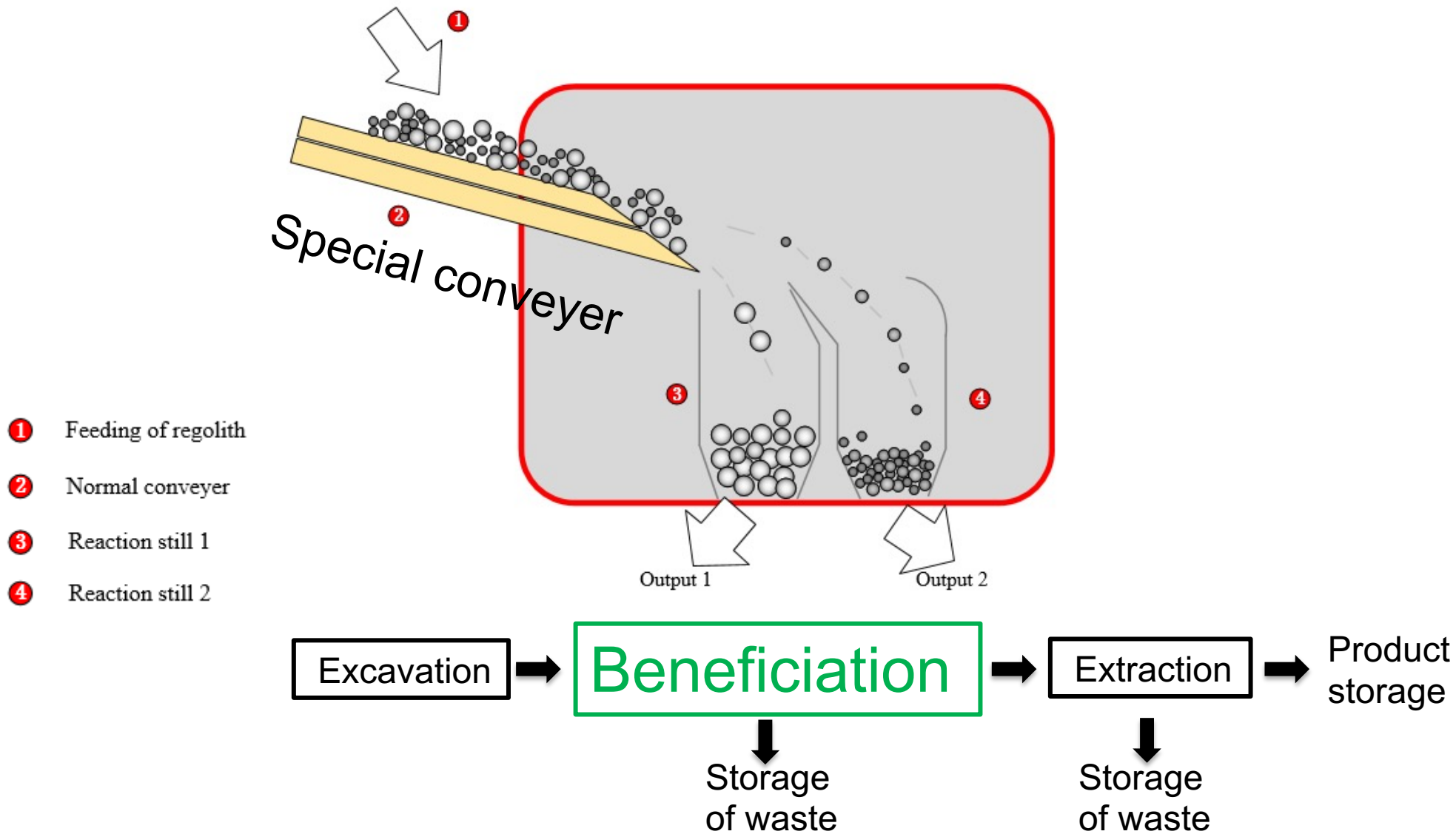
**1 Background**

**2 Electrostatic traveling wave method**

**3 The effect of dielectrophoresis**

**4 Experiment results**

**5 Conclusions**



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**1 Background**

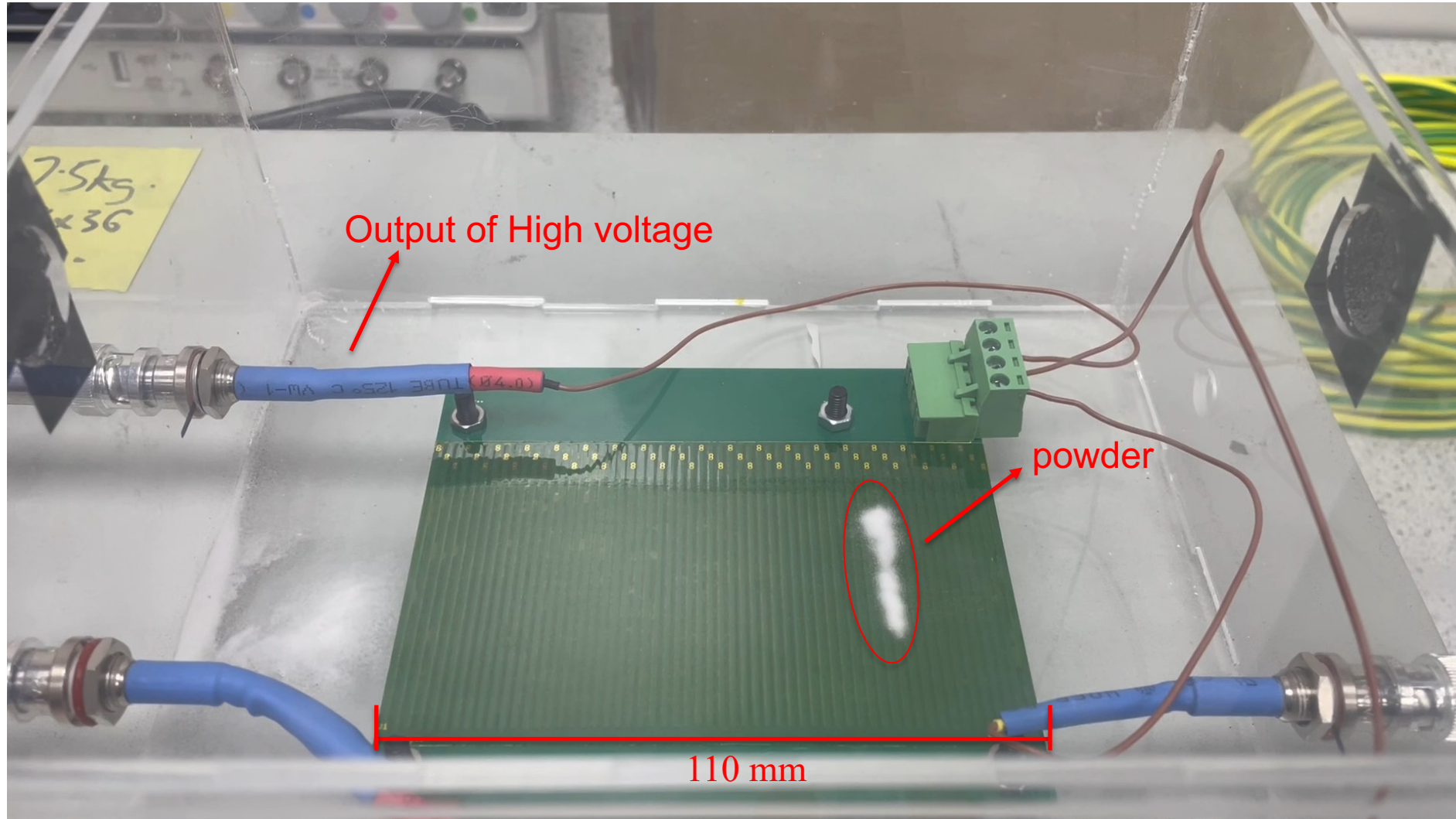
**2 Electrostatic traveling wave method**

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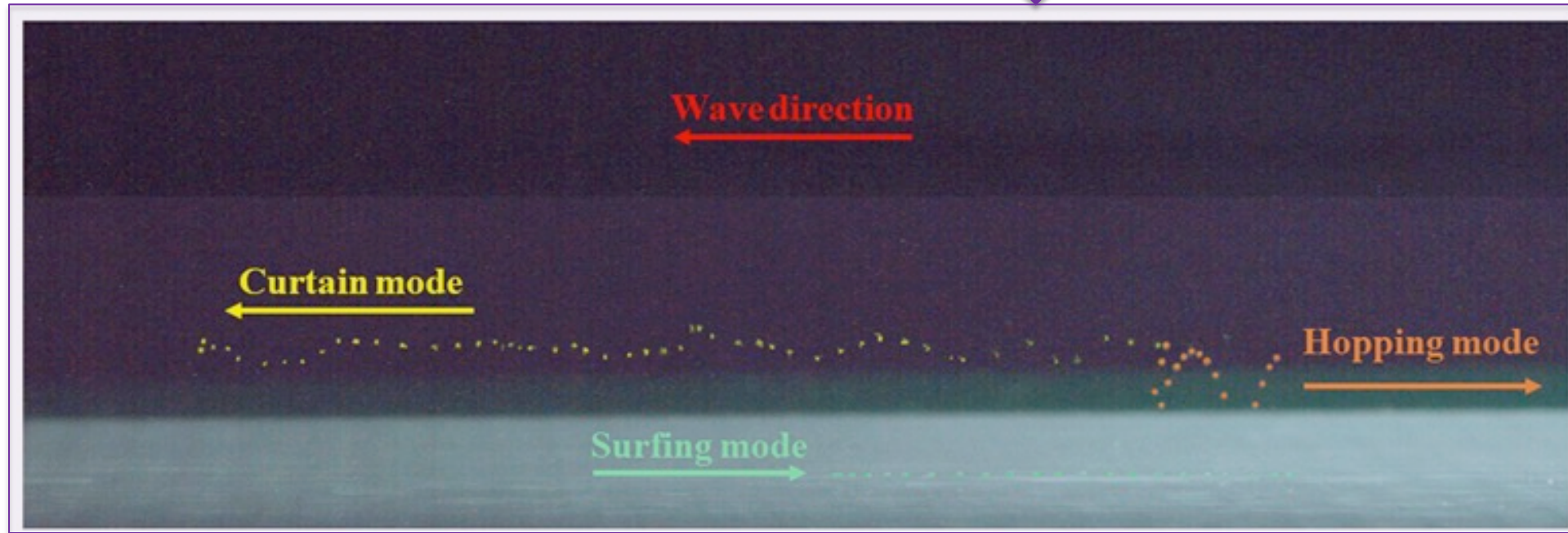
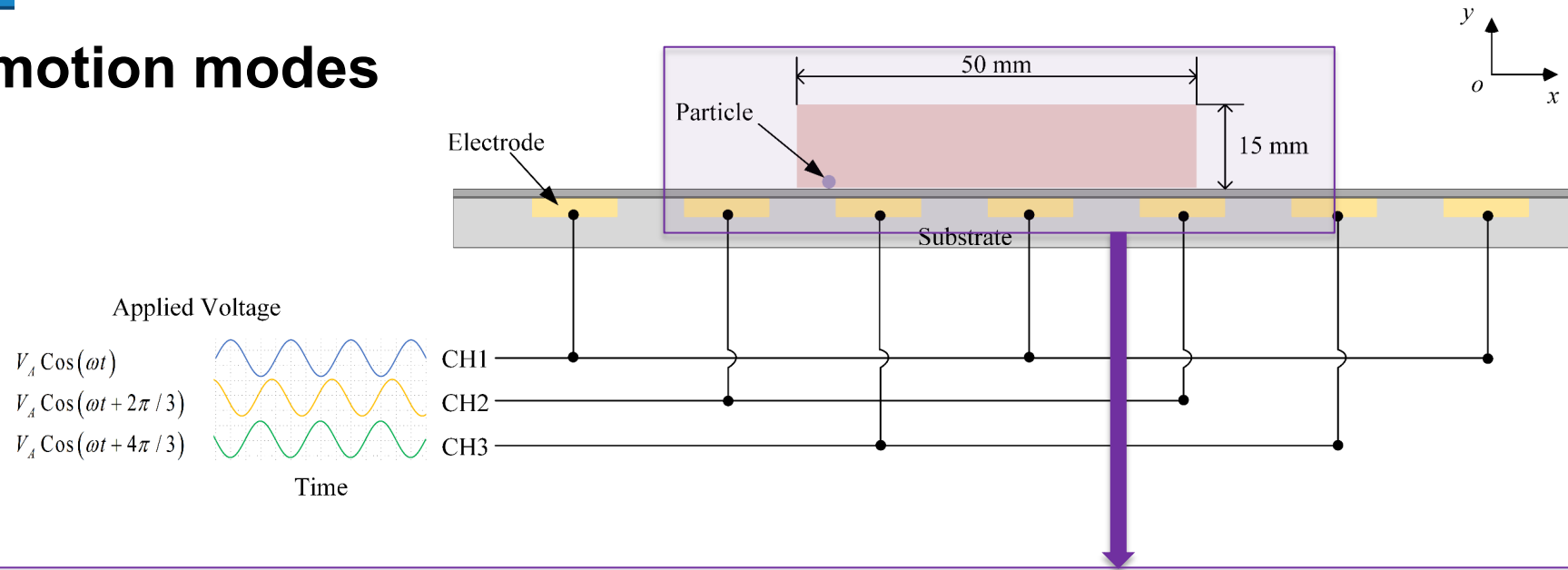
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## Electrostatic traveling wave (ETW) method



# Particle motion modes



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**1 Background**

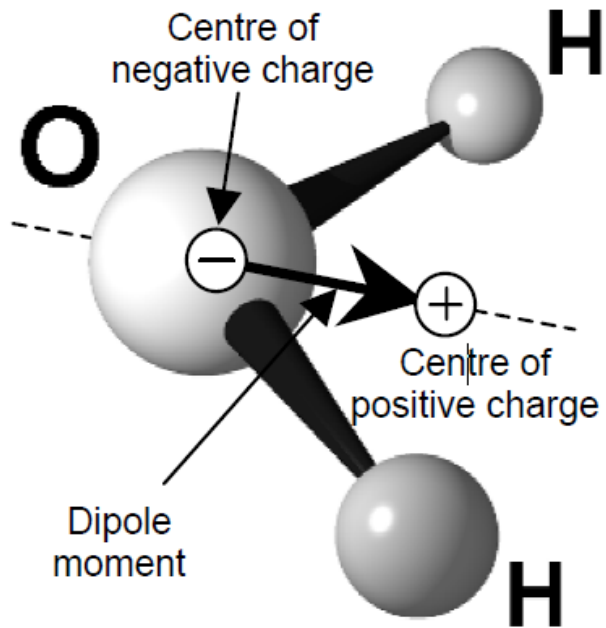
**2 Electrostatic traveling wave methods**

**3 The effect of dielectrophoresis**

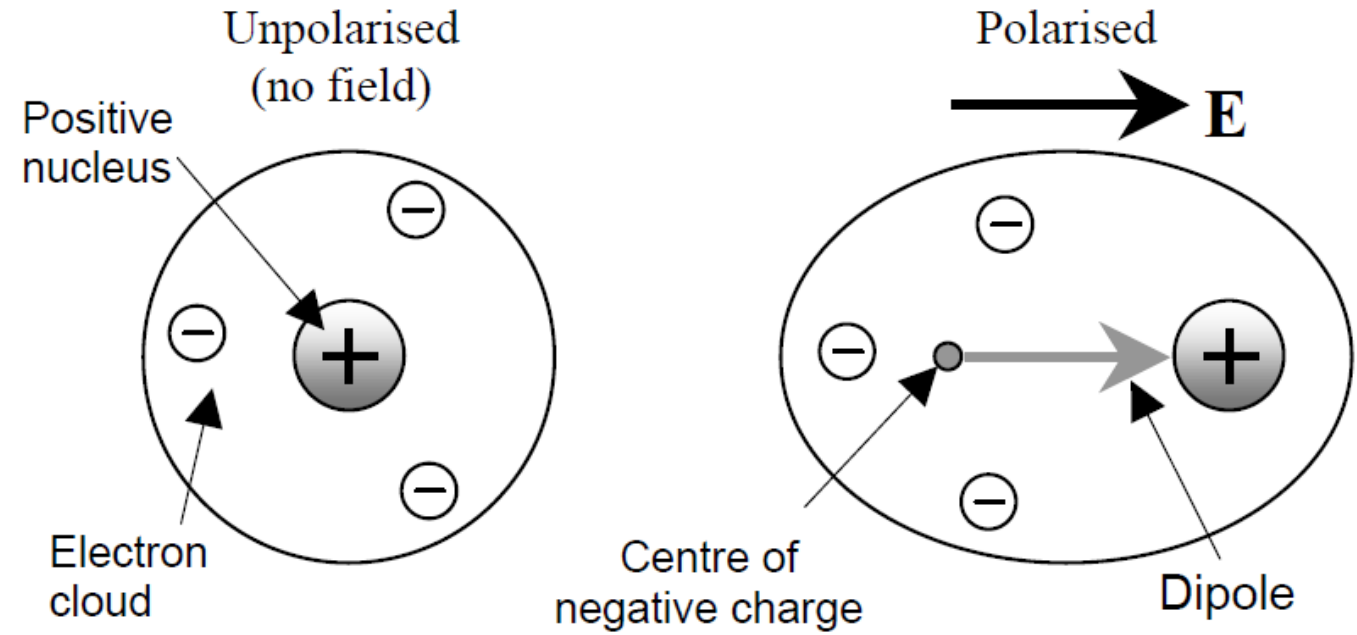
**4 Experiment results**

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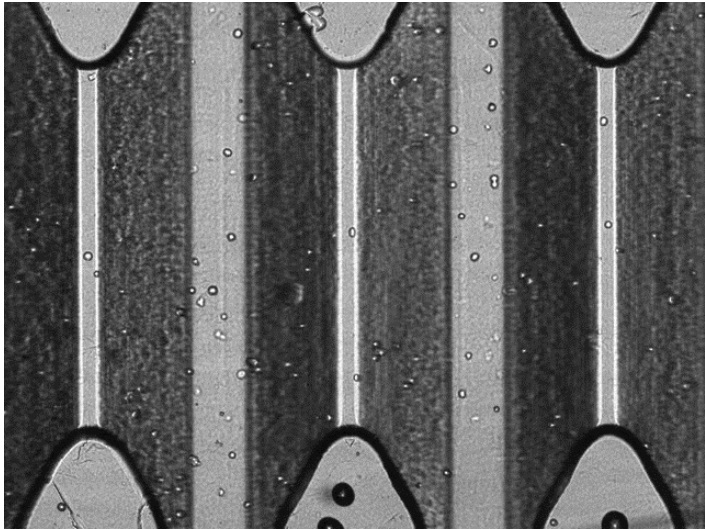
# Dipole



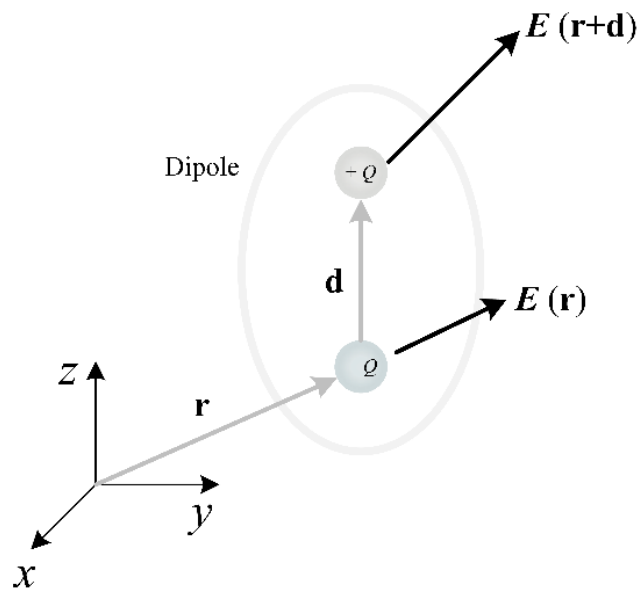
Permanent dipole



Field induced dipole



Biological cell separation (Beer et al., 2017)



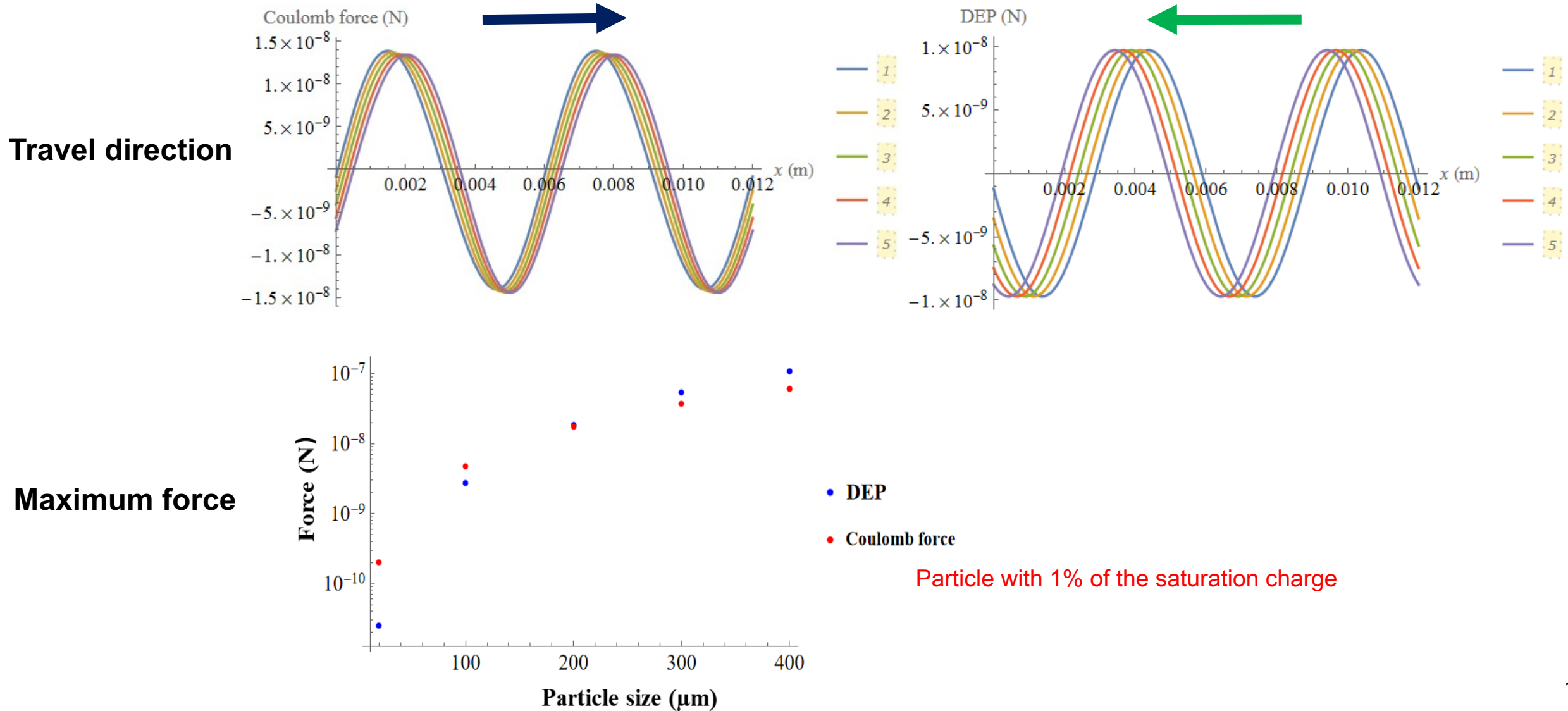
Dipole moment  $\mathbf{p} = Q\mathbf{d}$

$$\begin{aligned}\mathbf{F} &= Q\mathbf{E}(\mathbf{r} + \mathbf{d}) - Q\mathbf{E}(\mathbf{r}) \\ &= Q\mathbf{E}(\mathbf{r}) + Q(\mathbf{d} \cdot \nabla)\mathbf{E} + \text{higher order terms} - Q\mathbf{E}(\mathbf{r}) \\ &= Q\mathbf{E}(\mathbf{r}) + Q\left(dx \frac{\partial}{\partial x} + dy \frac{\partial}{\partial y} + dz \frac{\partial}{\partial z}\right)\mathbf{E} + \text{higher order terms} - Q\mathbf{E}(\mathbf{r})\end{aligned}$$

Neglecting the higher order terms gives:

$$\mathbf{F}_{DEP} = (\mathbf{p} \cdot \nabla)\mathbf{E}$$

## Comparison of DEP and Coulomb force

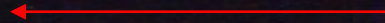


Polyethylene



Diameter : 300-400  $\mu\text{m}$   
Density :  $0.7 \cdot 10^3 \text{ kg/m}^3$   
Relative permittivity : 3.2  
Easy to get charge

Wave direction (wave length = 6 mm)



46.8 mm / 0.28 s = 167 mm/s

Frequency: 30 Hz

Wave velocity:  $30 \cdot 6 = 180 \text{ mm/s}$

Motion direction



50.8 mm / 0.14 s = 362 mm/s

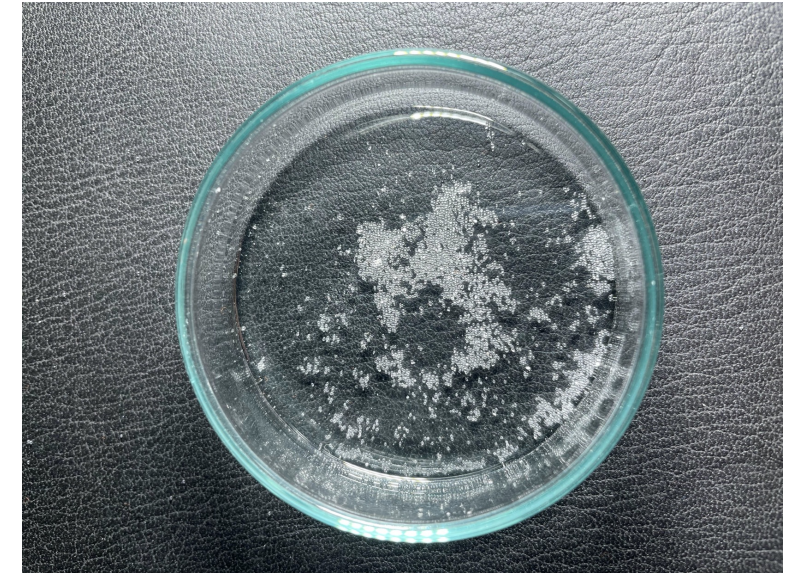
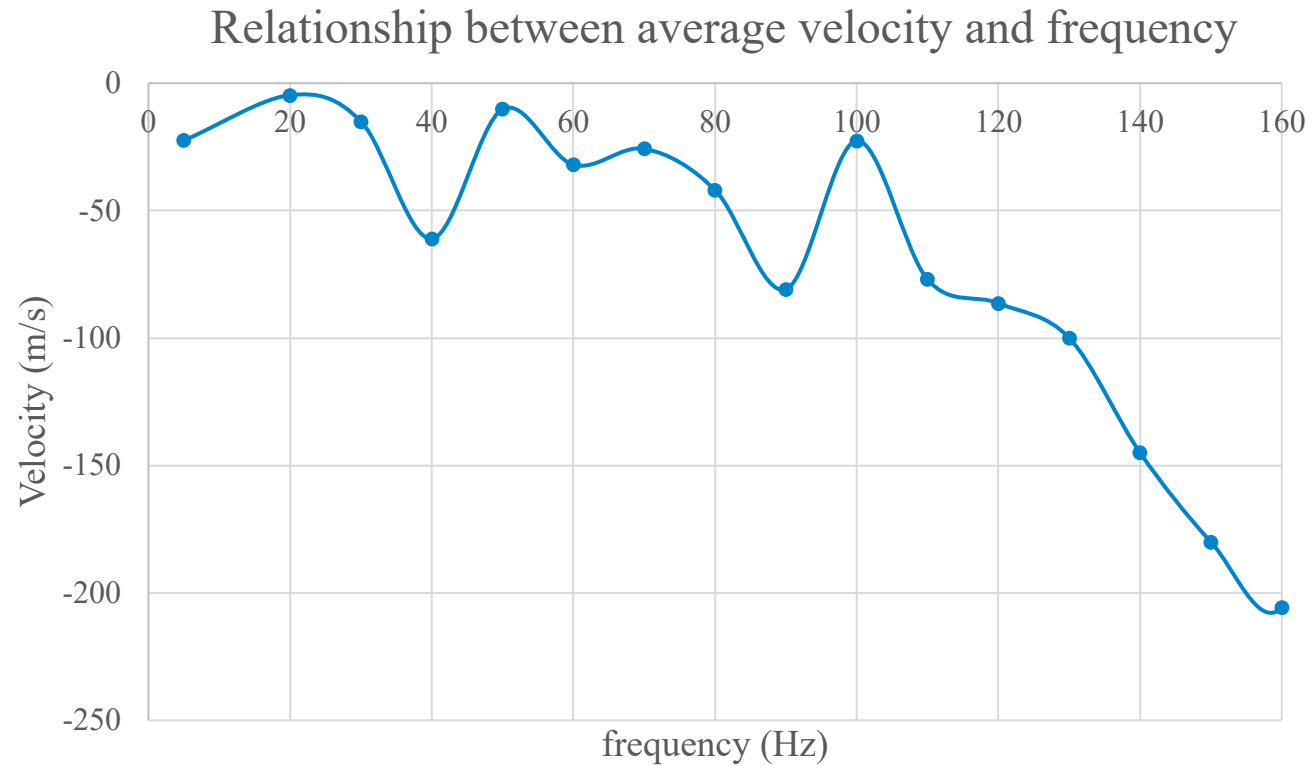
Frequency: 60 Hz

Wave velocity:  $60 \cdot 6 = 360 \text{ mm/s}$

Motion direction



## Ballotini



Diameter : 300-400  $\mu\text{m}$   
Density :  $2.5 \cdot 10^3 \text{ kg/m}^3$   
Relative permittivity : 3.7  
Hard to get charge

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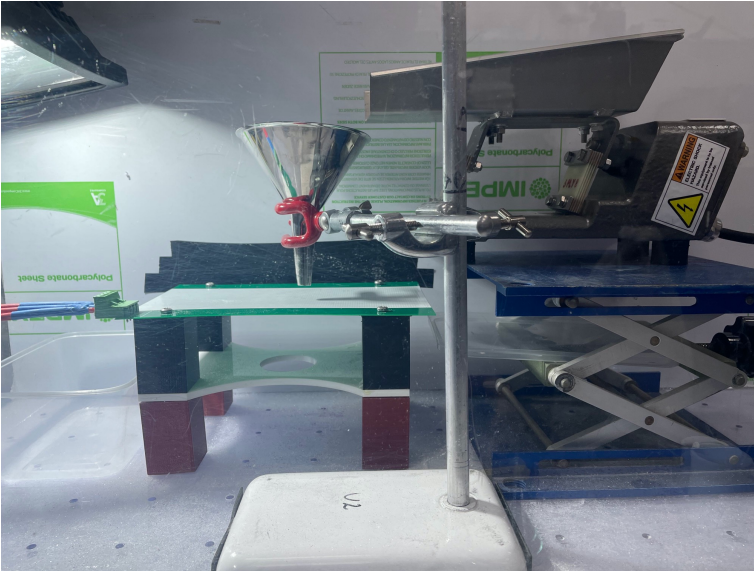
## Particle transportation

| Particle size        | Voltage amplitude | Voltage frequency | Wave direction  | Total mass: 5 g            | Total mass: 10 g           |
|----------------------|-------------------|-------------------|---|----------------------------|----------------------------|
| 70-110 $\mu\text{m}$ | 1500 V            | 20 Hz             |  | Forward collection: 4.88 g | Forward collection: 9.63 g |

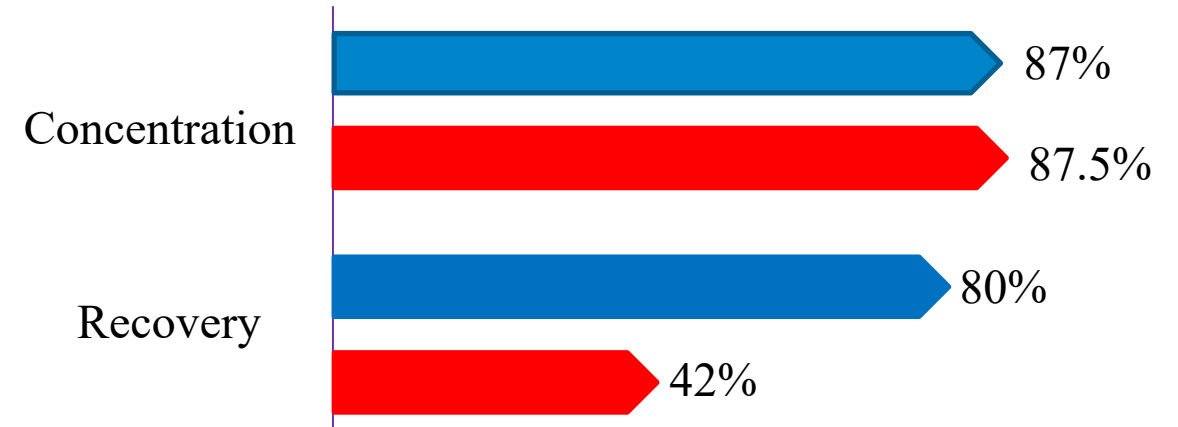
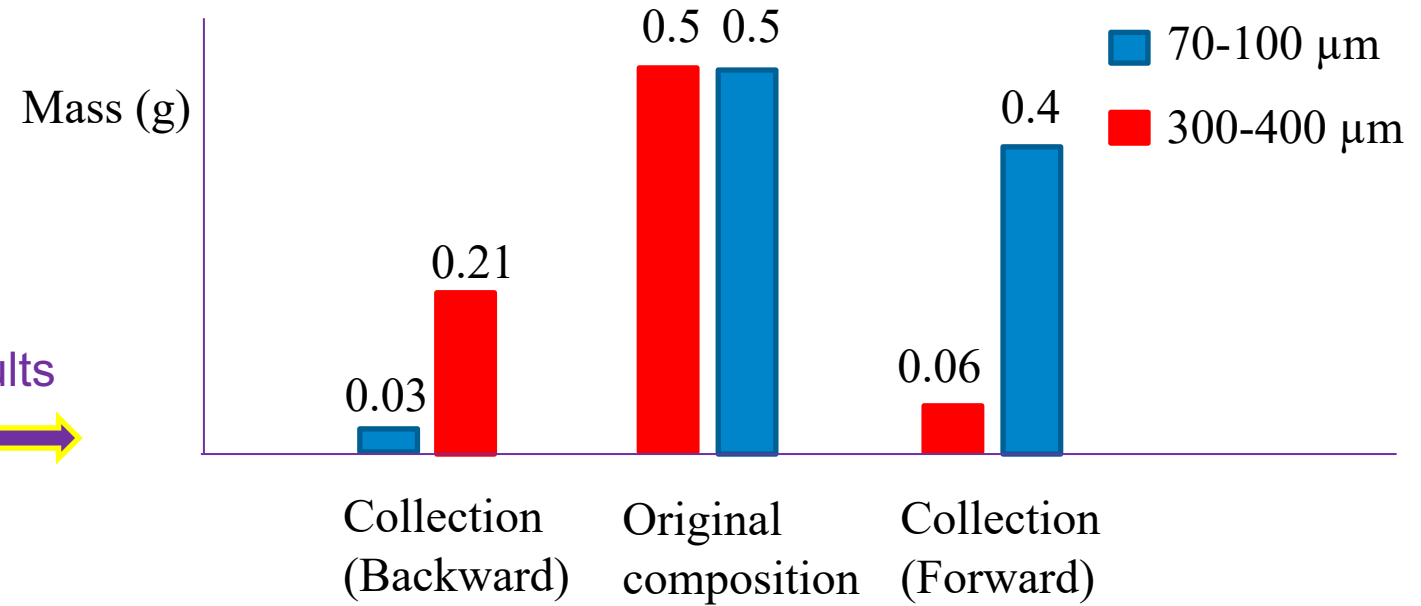


## Particle Separation 1

Voltage amplitude: 1500 V  
Voltage frequency: 160 Hz



Results



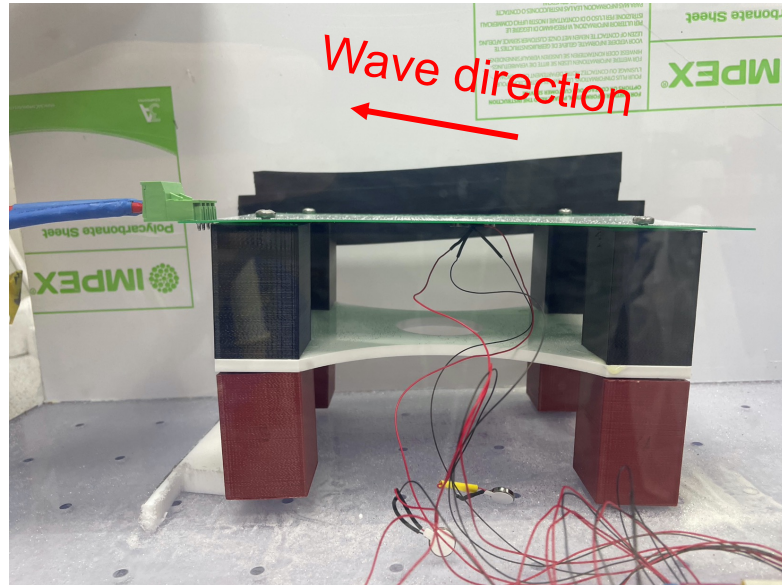
## Particle Separation 2

Voltage amplitude: 1500 V

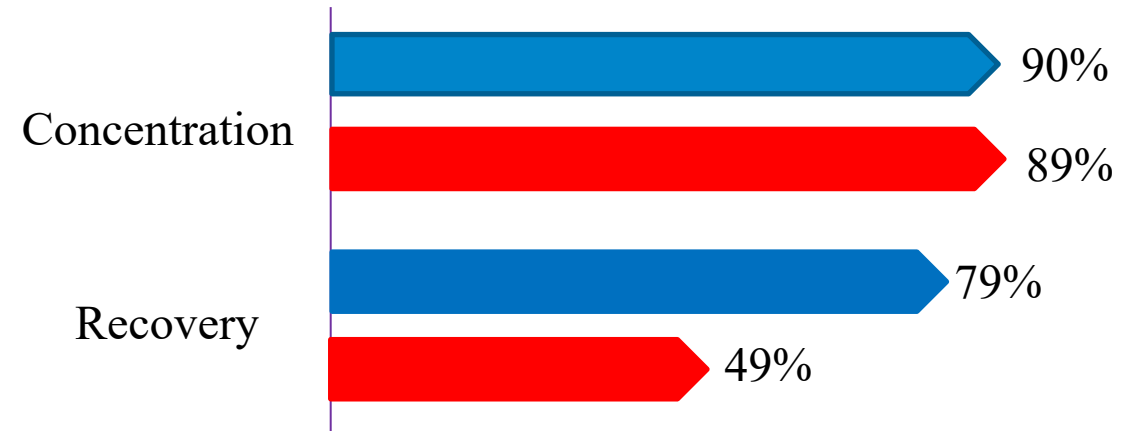
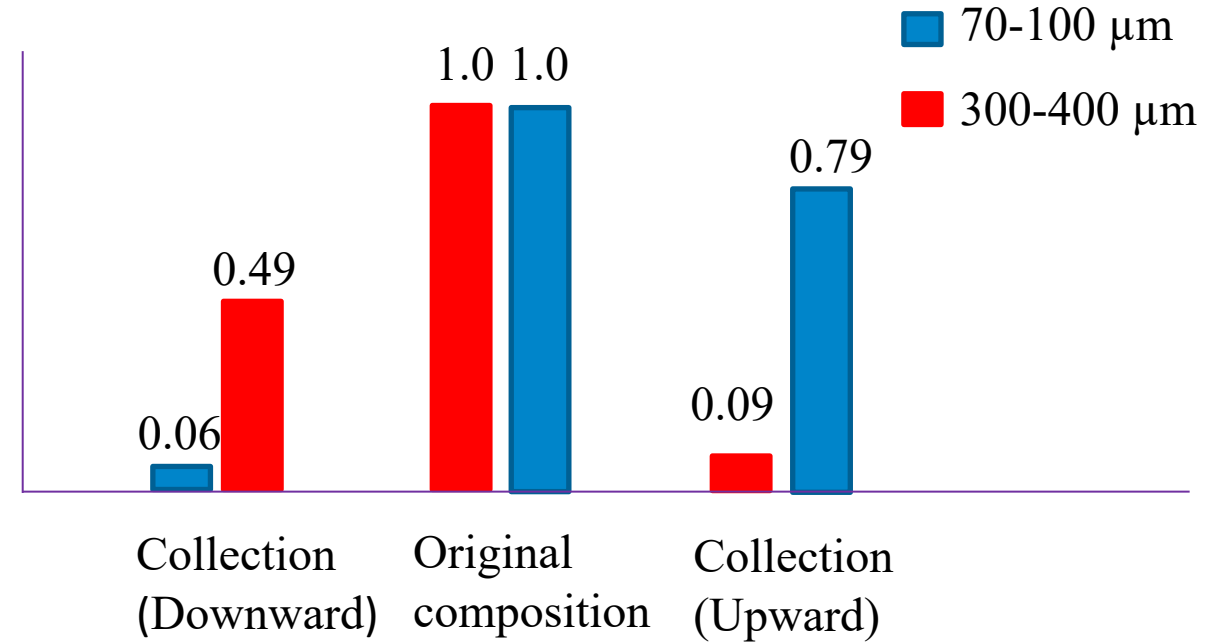
Voltage frequency: 160 Hz

Other factors :Vibration, tilt angle and feed rate

Mass (g)



Results



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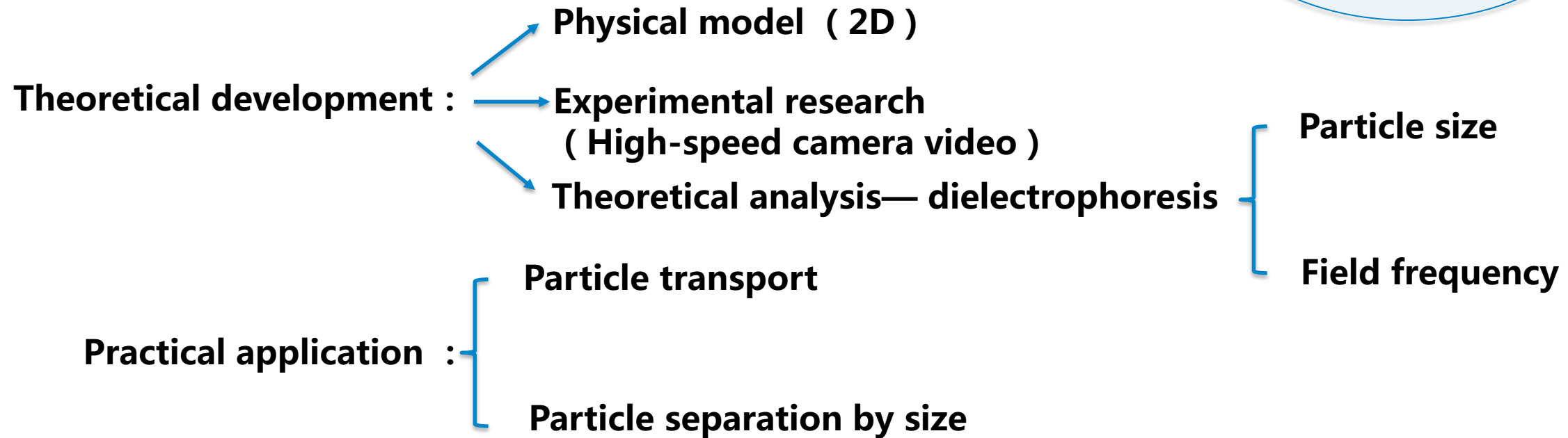
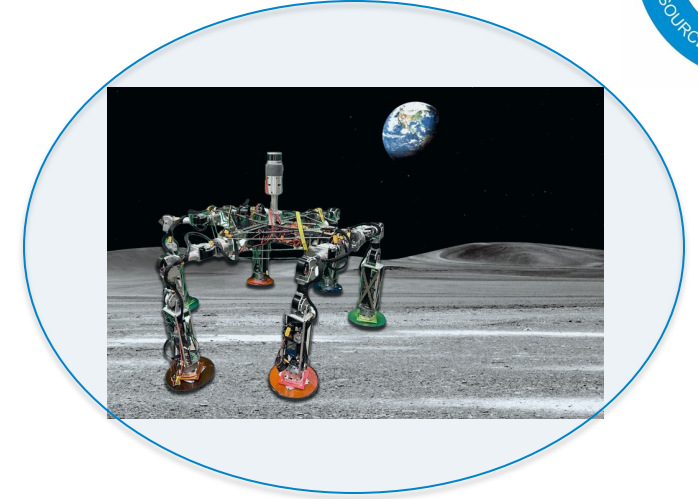
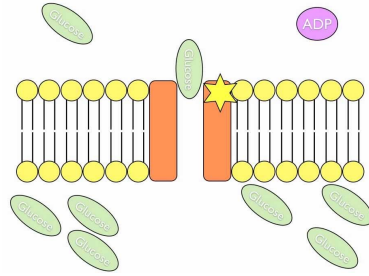
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## Overview

**Applications :**



## Conclusions

- The effect of dielectrophoresis on particle's motion has been revealed
- The ability for the transport of large amount of small particle has been verified
- Different sizes of particles have been separated in terms of different motion directions