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Clarification of Colloidal Particles in Lake and River Water Using AC Electrokinetic

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Abstract. Scenery of clear water of a lake or river is always a fascinating view. The clarity of a water is subjected to the water free from colloidal particles. Lake or river usually have foreign colloidal particles such as sand, mud, foreign particle, etc. which make the water cloudy. Usually the cloudy water become clear because of natural sedimentation process. However it is not easy to clarify cloudy water of a lake or river and make it clear especially if the sediment of colloidal particle is influence or disturb by water current. The approach by AC Electrokinetic phenomenon able to manipulate colloidal particles in a suspension. It can separate, trap or sort colloidal particle which made the phenomenon as possible reliable option for clarifying lake or river water from colloidal particles hence make it clear water. This work will simulate the process of clarification of colloidal suspension using AC Electrokinetic phenomenon in a lab. Electrodes were fabricated on Indium Tin Oxide (ITO) coated glass slide using laser etching technique. The electrode which poses unique geometry will be able to demonstrate electric field gradient as soon as it is introduced with electrical signal. Base on the surface potential of the colloids and the surface potential of the electrode, the colloids will be manipulated. This phenomenon is known as AC Electrokinetics. This can be regarded as guided sedimentation process. The trapped colloidal particle can be now easily extracted or remove from the water thus transform the water from cloudy to clear hence complete water clarification process.

1 Introduction

Injection Crystal clear water of a river or lake is always be an attraction, be it to the local community or to the tourist. As world is threat by pollution there are not many river or lake that maintain its crystal clear water. Many efforts have been done to regain the clarity of the water.There are many techniques that have been introduced to clarify or purify water such as filtering technique, biotechnology technique (using micro bacteria), etc.[1] This paper introduced electrical approach as additional option for clarifying water by manipulating colloidal particles using electrical field. The manipulated colloids is then can be set for

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removal to transform cloudy water to clear water. The phenomenon for manipulating colloids in suspension using electric field is known as AC Electrokinetics. There are two conditions where AC Electrokinetics take part, either electric field directly manipulate the colloidal particles which is known as Dielectrophoresis (DEP) or the electric field induces motion to the suspending medium where it subsequently will manipulate the colloids which is known as AC Electroosmosis (ACEO) [3].

Electrode with specific geometry needs to be fabricated in order to utilize electric field for manipulating colloids [2]. The electrodes were micro fabricated on Indium Tin Oxide (ITO) coated glass slide using laser etching technique. In previous works the micro fabrication were done using lithography techniques [3][4][5] The laser etching techniques is easy to use and applicable practically to the whole classes of materials, such as silicon, germanium, glass, oxides, nitrides, salts, alloys, binary and ternary compounds and alloys and metals. The laser etching is done using Resonetics RapidX250-L Series as shown in Fig. 1. Resonetics RapidX250-L is a laser-based laser micromachining systems designed to fabricate micro-machined components. The system is capable to fabricate up to 1µm in size.

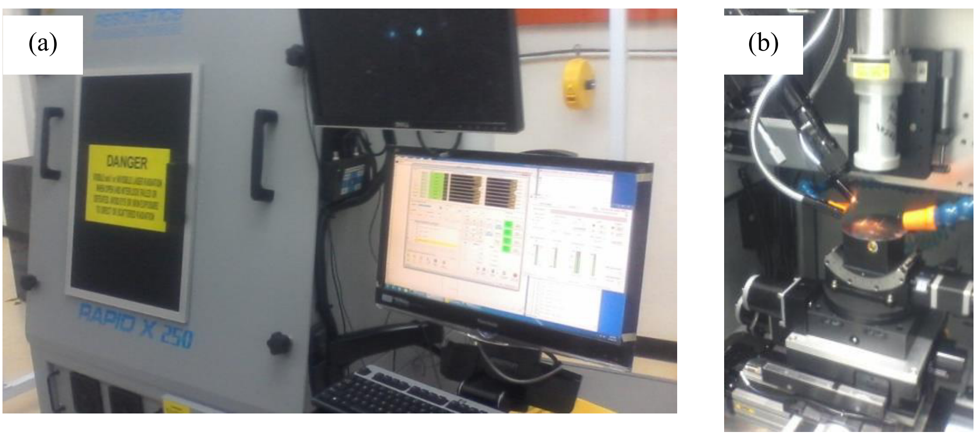

Fig. 1. (a) Resonetics RapidX250-L Series, (b) The stage where the samples were mounted.

The samples used for this work were controlled size colloids; 3.1 µm in diameter Fluorescent Polymer Microspheres purchased from Duke Scientific Corporation (Palo Alto, CA, USA), and specimens were taken from cloudy water from a lake in Serdang, Malaysia.

2 Methodology

2.1 Electrodes

The electrodes were fabricated on the ITO coated glass using laser etching technique. The geometry of the electrodes was designed using computer aided drawing (CAD) software. This work used zipper geometry as used by Mohtar et. al. [3] and Hoettges et. al. [5]. Zipper geometry is selected because the geometry will have electric potentials of opposing polarity applied allowing focusing of particles across a large area toward a central spot. The CAD drawing of zipper geometry is used by Resonetics RapidX250-L laser micromachining system in order to etch ITO on the ITO coated glass to produce the zipper electrode geometry. The ITO is used because it is transparent. This is important during the real time observation under the microscope. The fabrication process is carried out in a cleanroom because the low level of environmental pollutants such as dust, airborne microbes, aerosol particles, and chemical vapors can cause disturbance to the final results of the fabrication. Fig. 2 shows the electrode used during the experimental work. A chamber of 390 µm height is build enclosing the electrode for the optimal condition as in previous work done by Mohtar et. al. [3].

Fig. 2. Zipper Electrode 500 µm diameter, 100 µm inter electrode gap micro fabricated using laser etch technique as used in the experiment.

2.2 Sample preparation

Two set of samples were prepared for this work. Sample A is a control samples prepared using Fluorescent Polymer Microspheres, 3.1 µm in diameter purchased from Duke Scientific Corporation (Palo Alto, CA, USA). It was used because the size makes the particles easily seen through normal light microscope without the need of using fluorescent microscope. The stable properties of the latex bead acts as a constant to avoid the particles to have variables that can affect the experiment. They were supplied as dyed polystyrene microspheres in water with 6.7 x 108 beads/ml concentration. The aqueous polymer microsphere is diluted to 104 beads/ml using deionised water to get a single layer collection of particle [3]. Sample B is cloudy water taken from a lake in Serdang, Malaysia with an unknown colloids as shown in Figure 3. Both samples were shake using vortex shaker for 60 seconds before undergo ultrasonic shaker for evenly distribute the colloidal particles in the suspension.

Fig. 3. Cloudy lake water taken from a lake in Serdang, Malaysia.

2.3 Particle separation

The sample (20 µl – 50 µl) was pipetted onto the electrodes array and covered with a glass cover slip thus stay in a chamber. Electric potentials were applied using a function generator giving 10 Vp-p at 1 KHz frequency for 1000 seconds. The experiment is observed using Nikon Eclipse Ni-U microscope. Particle collection was observed and image is taken using Nikon NIS-Elements BR 4.20.00 software.

3 Results and discussion

As soon as the electrical signals were introduced to the electrodes, diagonal movement of the particles toward the center of the electrodes can be observed. Image of collected particles after 1000 s for Sample A is as shown in Figure 4 and for Sample B is as shown in Fig. 5.

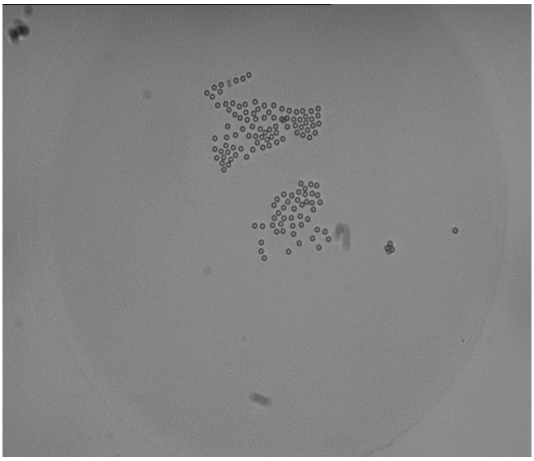

Fig. 4. Collection of particle for Sample A on a Zipper electrode 500 µm diameter, 100 µm inter electrode gap, applied to 10 Vp-p, 1 KHz, after 1000s.

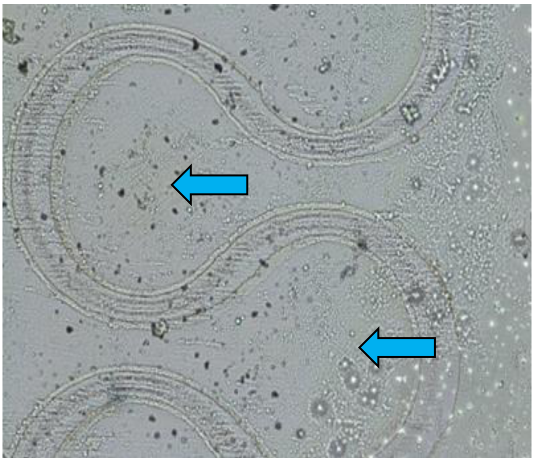

Fig. 5. Collection of particle for Sample B on a Zipper electrode 500 µm diameter, 100 µm inter electrode gap, applied to 10 Vp-p, 1 KHz, after 1000s.

The electrical signal of 10 Vp-p, 1 KHz were choose for this experiment because it was proven as the optimal electrical signal needs to be applied in previous study [3]. The vortex motions can be observed at the edge of the electrodes before the particles move diagonally towards the center of the electrodes and trapped. This suggested that the electric field induced motion to the suspension medium hence ACEO were occurred. It has also been observe that when the frequency is change to 100 Hz for both samples the particles were collected at the electrode edge. This suggested that the electric field acts directly on the particles hence DEP were occurred. This has confirmed the previous works done by Mohtar [3], Hoettges [5] and Hubner [6]. This has also means that the manipulation of colloids is selective according to the electrical potential supplied.

4 Conclusions

This work has shown that it is possible to manipulate colloidal particles in a suspension using electric field. This work has been able to trap particles of known size (3.1 μm) and unknown size (which were later found out to be 8-10 μm when measured using Nikon NIS-Elements BR 4.20.00 software) using electric field known as AC Electrokinetic. Both phenomenon either DEP or ACEO which were discussed earlier manage to trap the particles to the electrode. In future, this experiment in the lab using small scale model can be introduce for real scale study for clarification process of lake, river, etc. The selectivity of the manipulation is one of the advantages over filtering method as it can choose what to trap and remove and what to be left remain.

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References

1. N. Spahis, A. Addoun, H.Mahmoudi, N. Ghaffour, Desalination, **222**, 519 (2008)
2. H.A. Pohl, K. Pollock, J. Electrostat., **5**, 337 (1978)
3. M.N. Mohtar, K.F. Hoettges, M.P. Hughes, Electrophoresis, **35**, 345 (2014)
4. N.A. Kadri, K.F. Hoettges, M.P. Hughes, *4th Kuala Lumpur International Conference on Biomedical Engineering* (2008)
5. K.F. Hoettges, M.P. Hughes, A. Cotton, N.A. Hopkins, M.B. McDonnell, IEEE Eng. Med. Biol. Mag., **22**, 68 (2003)
6. Y. Hubner, K.F. Hoettges, M.B. McDonnell, M.J. Carter, M.P. Hughes, International journal of nanomedicine, **2(3)**, 427 (2007)