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An Attempt for Improvement of Water Quality and Cultivation of Plankton by Conducting Polymers

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ABSTRACT

We conduct cultivation of paramecium in the presence of polyaniline as an electroactive-conducting polymer. The polyaniline employed in this study is in a form of half-doped state. The half-doped state partly has acid as a dopant in the main-chain. Paramecium discharges ammonia because no Ornithine cycle exists in their organs, resulting the discharged ammonia pollutes water environment. The half-doped state of polyaniline absorbs ammonia as a neutral agent. This function of electroactive polymer can be useful for purification of water. Furthermore, the conducting polymers have capturing function of heavy metals. These characters of the conducting polymer can be expected to improve the water quality for biological system. Cultivation of paramecium in the presence of the polyaniline depress the increase of pH with time. However, film form of the polyaniline could not improve the increase of pH in the cultivation system. Oxidation-reduction potential (ORP) value of the cultivation water in the presence of polyaniline is also monitored.

1. INTRODUCTION

Plankton in the water system does not possess Ornithine cycle, resulting discharge of ammonia as a poison chemical. In the case of mass generation of plankton occasionally, discharge of ammonia from the plankton deteriorates the environment. We have studied on conducting polymers for cultivation of microbes in the water [1,2]. Half-doped state of the conducting polymers as a characteristic electronic state can neutralize ammonia without any negative effect against biological system in the laboratory. In this research, we cultivate a microorganism and measure change in pH and ORP. We discuss possibilities for improvement of water environment system using this unique advantage of conducting polymers.

2. MATERIALS AND METHOD

Polyaniline as a conducting polymer was prepared with oxidative polymerization with ammonium persulfate (APS). As prepared polyaniline was treated with ammonia/water to remove excess amount of acid dopant. The as prepared polyaniline (full doped state, emeraldine salt) cannot be employed for cultivation of paramecium due to strong acid. Polyaniline thus obtained is half-doped state (reduced) as emeraldine base (PANI-EB) form, remaining small parts of acid fractions in the main-chain (Scheme 1). Polyaniline cast film was prepared from polyaniline/*N*-methylpyrrolidone (NMP) solution. Fig. 1 shows an example of the polyaniline film. Paramecium was provided by Fujishima lab. (Yamaguchi Univ., Japan). Fig. 2 shows optical microscopy and polarized microscopy images of the paramecium with transmission and reflection light.

3. RESULTS

Cultivation of paramecium in the presence of polyaniline was carried out. Fig. 3 shows change in pH of the cultivation water in the presence of polyaniline (powder form, normal PANI), camphor sulfonic acid (CSA), polyaniline film (PANI film), or control (no polyaniline).

Figure 1. A polyaniline film.

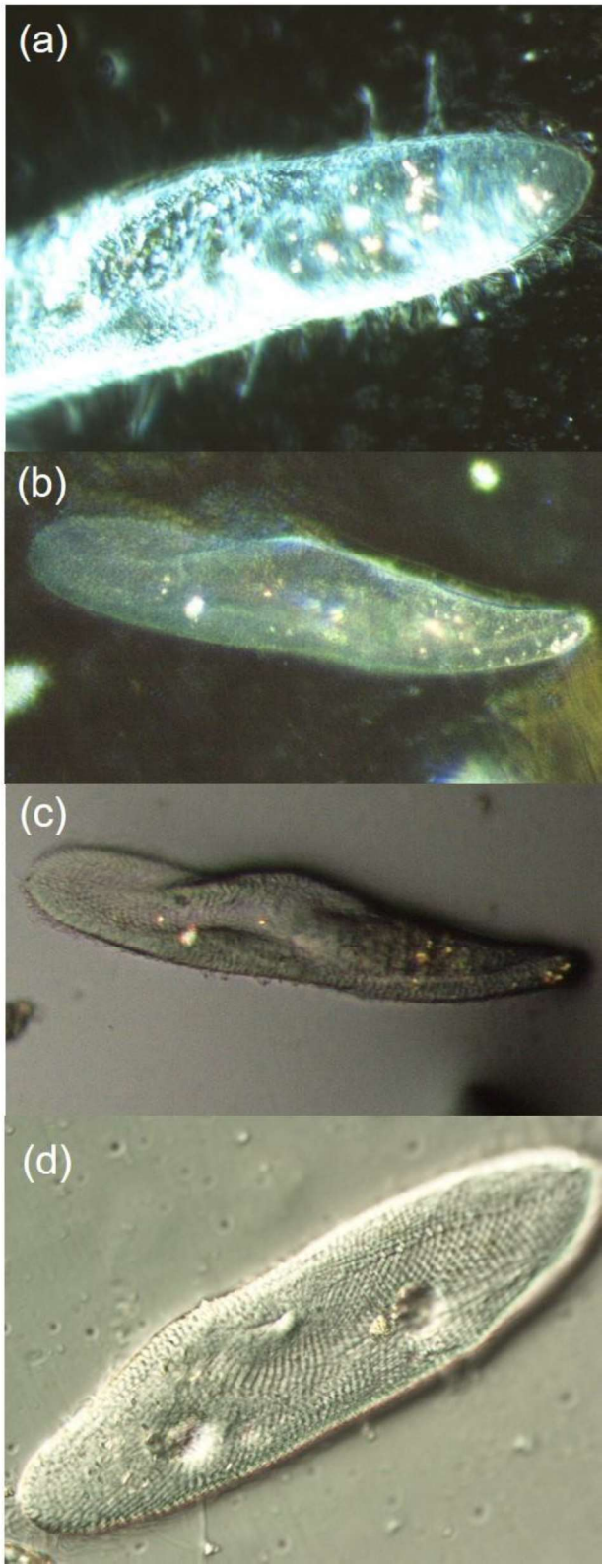
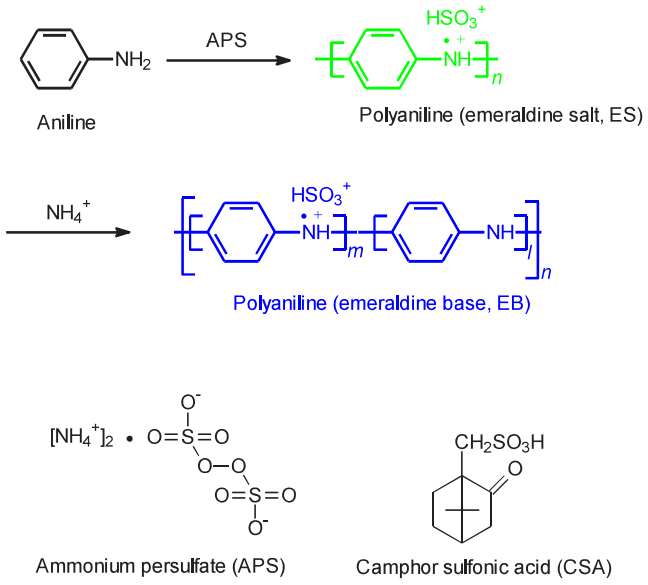


Figure 2. Optical microscopy images of a paramecium. (a) Optical microscopy images of paramecium with reflection light. (b) Optical microscopy image of moving paramecium with transmission light. (c) Optical microscopy image of moving paramecium with reflection light. (d) An entire figure of paramecium with transmission light.



Scheme 1. Synthetic route of polyaniline emeraldine base (PANI-EB) and molecular structure of camphor sulfonic acid (CSA). APS = ammonium persulfate.

The pH value increased with time because the paramecium in the water discharged ammonia. The polyaniline bulk (normal polyaniline, powder form) can suppress increase of pH value. Small amount of acid parts in the main-chain of the polyaniline (emeraldine base) neutralizes ammonia in the water. This function can provide a favor environment for cultivation of paramecium in the water. While, the polyaniline film could not effectively function for neutralization of the water.

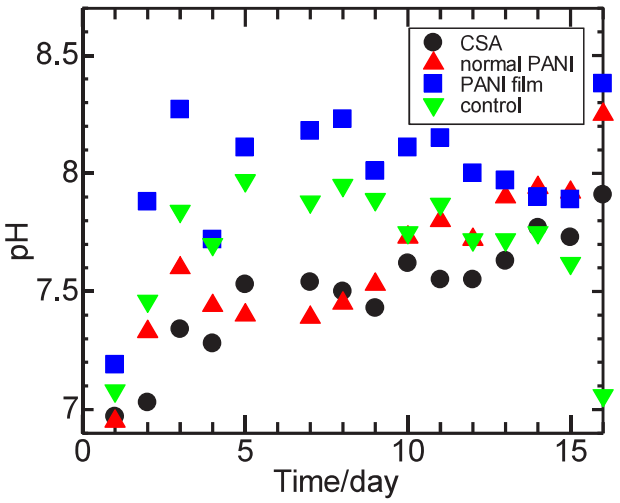


Figure 3. Change in pH value vs. time (day) of the water in the presence of paramecium, and polyaniline (powder form, normal PANI), camphor sulfonic acid (CSA), polyaniline film (PANI film), or control.

Fig. 4 shows oxidation-reduction potential (ORP) value of the cultivation water in the presence of paramecium as a function of time (days). Higher ORP value of the water was observed in the presence of CSA and normal polyaniline (powder form).

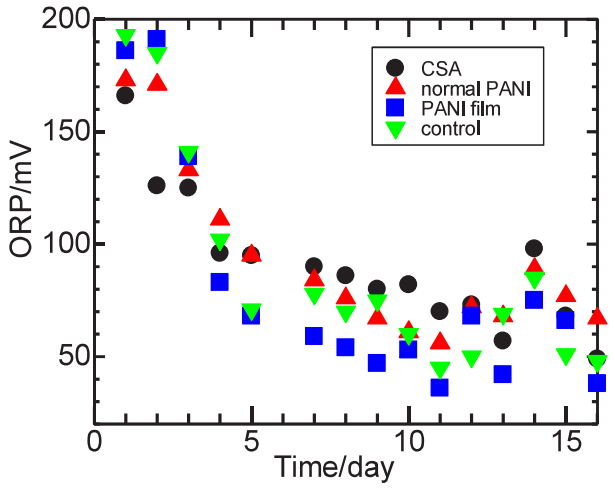


Figure 4. Change in oxidation-reduction potential (ORP) value vs. time (day) of the water in the presence of paramecium, and polyaniline (powder form, normal PANI), camphor sulfonic acid (CSA), polyaniline film (PANI film), or control.

4. DISCUSSION

Polyaniline emeraldine base functions as a neutralizer for the water in the presence of paramecium. The ammonium element discharged from paramecium becomes biological poison in the water environment. Polyaniline as a conducting polymer can absorb ammonia or other discharged materials from microbes in the water.

It may purify the water suitable for living organism in the lake and improve the water environment. This research is a new attempt for the water purification using conducting polymers.

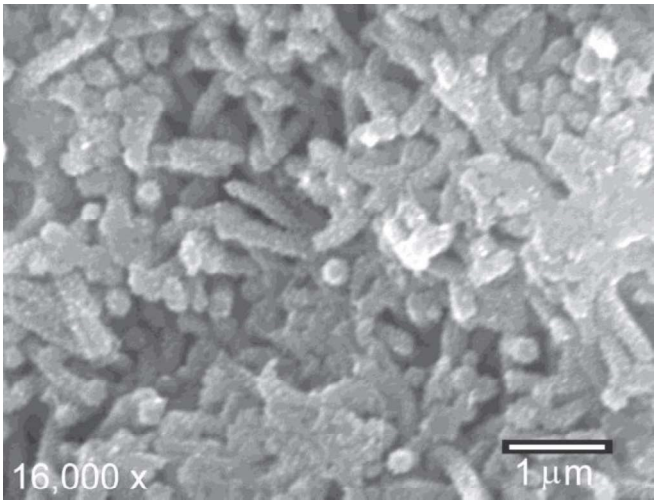


Figure 5. Scanning electron microscopy image of polyaniline prepared with camphor sulfonic acid (CSA).

5. FUTRUE ASPECT

Polyaniline forms several characteristic nano-structures. For example, polyaniline prepared with camphor sulfonic acid forms a nano-fiber structure（in this case small amount of a platinum complex [$Ph(CN)_2PtCl_2$] was added in the polymerization reaction. Ph = phenyl）[3], Fig. 5. Polymerization of aniline in the presence of polyvinylalcohol (PVA) can produce polyaniline microsphere [4]. Large surface area derived from the nano-structure can provide good contact with water to exhibit the water purification function. Materials with unique micro- or nano-structures have possibilities to show fine performance in environmental science. Conducting polymers are one of the candidates as organic functional material for it.

ACKNOWLEDGMENTS

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