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Electrochemical Process For Removal Of Color From Effluent Of Maize Based Starch Processing Unit

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Abstract: Electrochemical (EC) process for color removal of biodigester effluent of maize (corn) based starch industry wastewater (BDE-MSIWW) was investigated in a 1.5 dm^3 electrolytic batch reactor using aluminum as a sacrificial electrode. Experiments were conducted by the varying pH (4-10) and current density (CD) 51-255 A/m^2 (1-5 A) at 2.2 cm electrode gap. The color reduction of 97 %, 98 %, 67 %, 68 % and 44 % obtained at pH 4, 5, 7.8, 9 and 10 respectively. The color reduction also increased with current density. The best settling of slurry obtained at pH 9 and poorest at pH 4.
Keywords*:* Starch industry wastewater, Biodigester effluent, Electrochemical process.

1. Introduction

Maize (corn) is the major raw material for producing products like glucose and starch, which is a major ingredient in human diet. In integrated maize based starch industry each part of maize produces various valuable products like starch, glucose, maize oil, cattle and poultry fodder. For per ton of maize used in starch production about 8 m^3 water is consumed which generating 5.5 m^3 of waste water[1]. This wastewater has high organic load. Therefore, treatment of wastewater is required.

In the most of industries in India, composite effluent from integrated starch industry (pH 5-6) is not taken directly for anaerobic digestion treatment, but it is mixed with some effluent of bio-methanation reactor (pH 7.5-8). It is done to maintain optimum (pH~7) of the wastewater stream suitable for biomethanation process, which is sent back to bio-methanation (bio-digestion) reactor. The treated effluent from anaerobic biodigester is called biodigester effluent (BDE), which is fed to aerobic lagoon for bio-aerobic treatment. The discharge of aerobic lagoon contains COD 800-1200 which does not meet the discharge water quality standards to release into surface water (COD < 100 mg/dm^3) and sewers (COD < 300 mg/dm^3) applicable in India[2]. The black color of effluents is harmful for aquatic life because it reduces air diffusion and sunlight absorption, consequently hindered the photochemical reactions for self purification of the surface water. Due to this, the decolourization and the removal of COD from the BDE is of immense important from the environmental point of view.

Various methods have been suggested for treatment of organic wastewater. However, the treatment of starch industry wastewater requires greater attention. The bio-anaerobic treatment has been reported by some authors[3,4]. Duran – deBazua et al.[5] evaluated the two stage system consisting of treatment by anaerobic process followed by aerobic process. Through the same process the COD removal efficiencies of 89% is obtained in anaerobic process and 85% in aerobic process [6]. Since biological process reduces only the biodegradable compound, therefore in recent years some physico chemical process such as coagulation[7], EC[8] and thermal treatment[9] have been explored. These methods gave significant treatment results of various organic wastewaters. So, these methods can also be applied for treatment of starch industry wastewater.

In this paper, the EC process for treatment of BDE, from maize-based integrated starch industry have been presented. Investigation on color reduction in a batch EC reactor using aluminum electrodes with change in several parameters, namely current density (CD), initial pH (pH_i), electrolysis time have been carried out**.** Since in this process sludge is generated and needs to be separated form the treated effluent. Thus, separation by settling is also studied.

2. Experimental

2.1. Material

Biodigester effluent (BDE) used in the study was obtained from Raja Ram Maize Industry Pvt. Ltd. Rajnandgaon, Chhattisgarh, India. The analytical grade and laboratory grade chemicals of Merk India Limited, Mumbai, India were used in experiments. Aluminum plate was arranged from local market. The wastewater was obtained from the processing of maize for the manufacturing of starches, glucose syrups and by-products such as maize gluten (20-60% protein content) and maize germ oil.

2.2. Experimental Setup and Procedure

The lab-scale batch experimental setup was used to removal of color by electrochemical degradation process. Experiments were carried out in a 1.5 dm^3 reactor made up of Pyrex sheet. Aluminum plates having thickness 3 mm were used as electrode material. Dimensions of electrodes were 70×70 mm. The total effective surface area of the each electrode was 4900 mm^2. A gap of 10 mm was maintained between the bottom of the electrodes and the bottom of the cell for the movement of magnetic stirrer. The spacing between two electrodes was kept to 2.2 cm. The electrode plates were cleaned by abrasion with sand paper and treated with HCl solution (10%) followed by washing with distilled water prior to their use. For the power supply, the anode and cathode leads were connected to the respective terminals of direct current source contains ammeter and voltmeter. At the end of experiments the sample was filtered to remove sludge. The filtered liquid was used for color analysis.

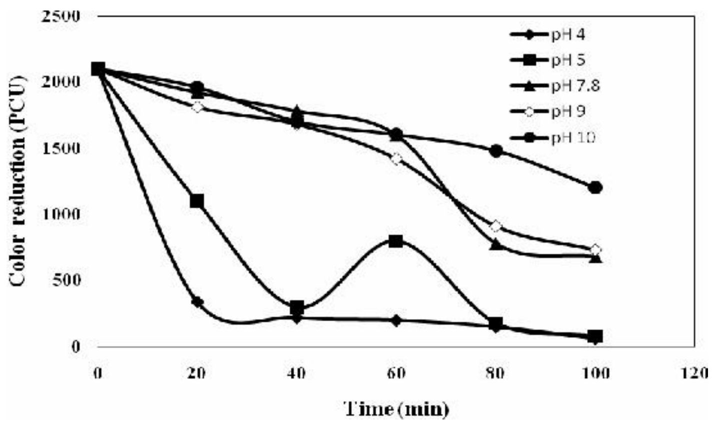

Figure 1. Effect of pH on color reduction of BDE-MSIWW. CD=153 A/m², g=2.2 cm.

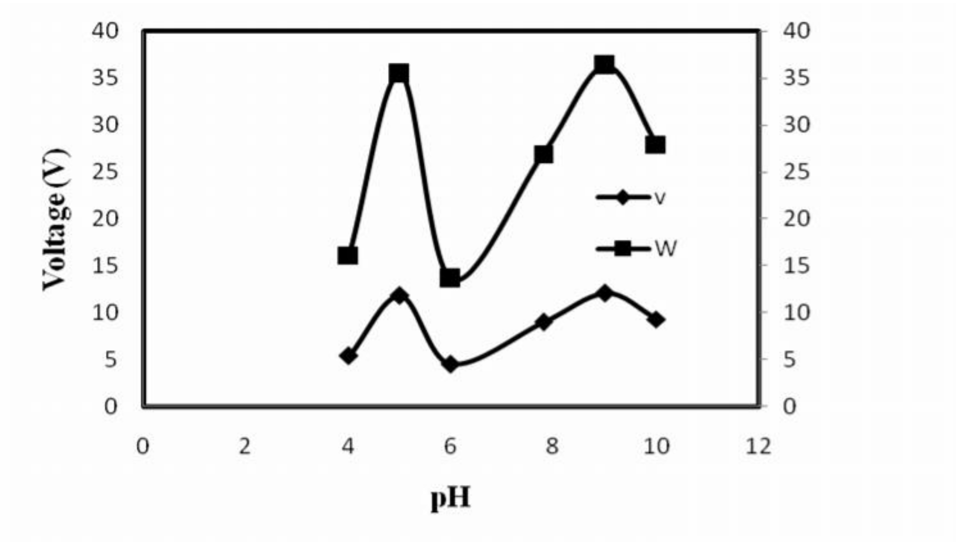

Figure 2. Variation in voltage and power at various pH for EC process

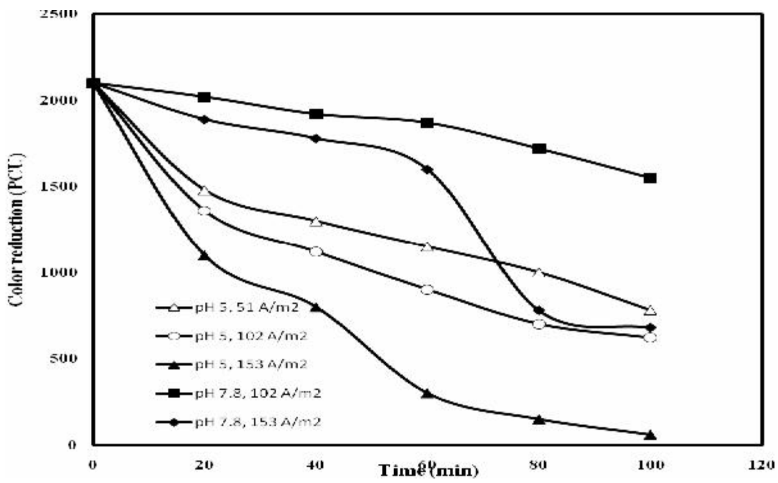

Figure 3. Effect of current density on color reduction of BDE-MSIWW. CD=153 A/m^2, g=2.2 cm

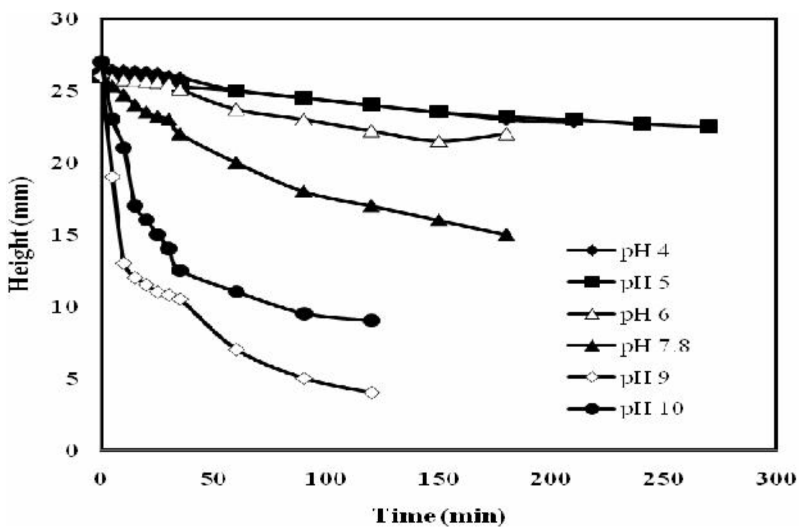

Figure 4. Settling of slurries

3. Result and discussion

3.1Eeffect of pH

The color reduction at different pH at current density 153 A/m^2 and electrode gap 2.2 c.m. has been presented in Fig 1. The color reduction are in order of pH 4> pH 5> pH 7.8> pH 9> pH 10. The results shows, the acidic pH gives better COD reductions. The reason for color reduction is separation of melonoidin from the wastewater during electrochemical reaction. The colloidal particles contain negative charge which combined with iron and hydrated iron oxide positive charge and neutralized, which, make heavy mass and settle down by gravity. The color of effluent reduced to 60, 70, 700, 740 and 1200 PCU from initial color 2100 PCU at pH 4,.5, 7.8, 9 and 10 respectively. These values shows 97 %, 98 %, 67 %, 68 % and 44 % color reduction.

Figure 2 shows the variation in voltage and power with pH at current density 153 A/m^2. The lowest power consumption of 12 Watt obtained at pH 6 while highest power consumption 36 W at pH 9. The variation in voltage and consequently power consumption is due to variation in resistance, which were found to pH dependent

3.2 Effect of current density

pH 3.5 is highly acidic. The good color reductions were also obtained at pH 5 and 7.8. Thus, at these pH the current density were varied and its effect on color reduction were estimated (Fig 3). The color reduction increases with current density. The color reaches to 750, 650 and 60 PCU at 5 pH and CD 51 A/m^2, 102 A/m^2, 153A/m^2 respectively. Operational pH 7.8 and current density 102 A/m^2, 153 A/m^2 reduces color to 1650 and 600 PCU respectively. The reason for increase in color reduction with increase in current density is avaibility of more cations which coordinated with negative colloidal parts contain in wastewater.

3.3 Settling studies

The settling study is necessary for separation of solids contain in slurry. The process was performed in a glass cylinder having 7 cm diameter and 500 dm^3 capacity. The settling was found in order pH 9> pH 10> pH 7.8> pH 6> pH 5> pH 4. The results are presented in Fig. 4. At pH 9 the 80 % settling was observed in 120 minutes.

4. Conclusions

i. Reduction of colors was pH dependent. The 97 %, 98 %, 67 %, 68 % and 44 % color reduction obtained at pH 4, 5, 7.8, 9 and 10 respectively.

ii. Increase in current density 51 to 153 A/m^2 was found to increase in color reduction.

iii. The variation in power consumption was found with pH. Least power consumption at pH 6 and highest power consumption at pH 9.

iv. The settling was found in order pH 9> pH 10> pH 7.8> pH 6> pH 5> pH 4.

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