Application of Dielectric Barrier Discharge Plasma for Reducing Chemical Oxygen Demand (COD) on Industrial Rubber Wastewater

Abdul SYAKUR[1], Badrus ZAMAN[2], Fauzan AFFIF[3], Siti NURJANNAH[4], Dias Yunita NURMALIAKASIH[5]
[1] Department of Electrical Engineering
[2,3,4,5] Department of Environmental Engineering
Engineering Faculty, Diponegoro University – Semarang, INDONESIA, 50275
E-mail : sensei2009@gmail.com

Abstract—**Dielectric Barrier Discharge Plasma (DBD) is one of cold plasma type. In this research, DBD plasma was used for reducing Chemical Oxygen Demand (COD) on industrial rubber waste. In the environment field DBD plasma is used as a water treatment and reduction of gas emissions (COx, NOx, and HC).**

In the development DBD plasma can be used as a wastewater treatment technology. Plasma is formed when a high voltage is supplied to the two electrodes. Electrodes used for this study is made of stainless steel and copper wire wrapped around pyrex pipes. Plasma as wastewater treatment technology uses high-voltage AC 50 Hz. Plasma from dielectric barrier discharge occurs when the electrode is given a high voltage to ionize water into active species. Plasma are generated depends on the amount of high voltage, configuration and electrode materials used, and the distance between the electrodes with a high voltage source.

Plasma reactor is operated by using a variation of voltage (10 kV, 11 kV, 12 kV and 13 kV) and contact time plasma with wastewater (5 minutes, 10 minutes, 15 minutes, 20 minutes and 25 minutes) with a batch system in processing wastewater to reduce amount of Chemical Oxygen Demand (COD) in wastewater processing natural rubber. Reducing COD contained in the waste because of the formation of the active species (O, OH, and O_3) to degrade the organic matter in the wastewater of natural rubber industry.

Keywords—*Dielectric Barrier Discharge (DBD) Plasma, Wastewater, COD, Natural Rubber Industry.*

I. INTRODUCTION

Dielectric Barrier Discharge (DBD) is the electrical discharge between two electrodes separated by an insulating dielectric barrier. Originally called silent discharge, and known as ozone producing discharge. The plasma itself is used to modify or clean surface of materials that can act as dielectric barrier, or to modify gases applied further. Some researchers have used plasma to removal gases radicals[1]–[5] and treating industrial wastewater[6]–[9].

Since the 19th century, DBDs were known for their decomposition of different gaseous compounds, such as NH_3, H_2S and CO_2. The relatively lower temperature of DBDs makes it an attractive method of generating plasma at atmospheric pressure

In this paper DBD plasma is used for treating industrial wastewater. COD is a parameter that is observed on the variation of the voltage value and duration of voltage application.

II. FUNDAMENTAL THEORY

A. Dielectric Barrier Discharge Plasma

Dielectric Barrier Discharges (DBD), also referred to as barrier discharges or silent discharges have for a long time been exclusively related to ozone generation. Detailed investigations into the properties of this non-equilibrium discharge which can be conveniently operated at about atmospheric pressure. Dielectric-barrier discharges are characterized by the presence of one or more insulating layers in the current path between metal electrodes in addition to the discharge space. Different planar or cylindrical configurations are common (Fig 1) closely related are surface discharge configurations in which discharges are initiated at a dielectric surface due to strong electric fields generated by imbedded metal electrodes. The presence of the dielectric(s) precludes dc operation[10].

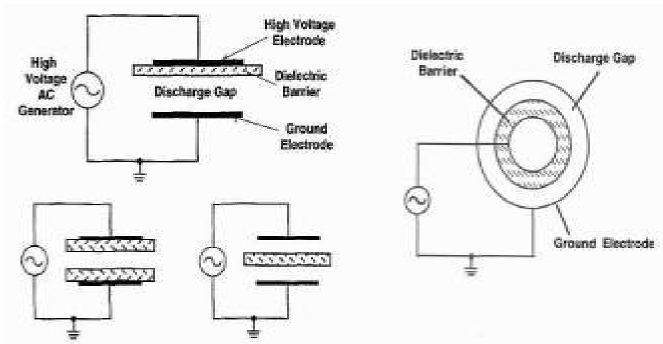


Fig. 1 Common dielectric-barrier discharge configurations

Plasma from dielectric barrier discharge was generated using air gasses free at atmospheric pressure as the gas input. Ozone is produced in the dielectric barrier discharge plasma of gas in the air or pure oxygen gas passing through the gap between two electrodes. Electron has high speed under high field. Under high filed electrons in the space between the electrodes, the dissociation of oxygen molecules.

B. *Vertical Roughing Filtration*

Vertical flow roughing filters operate either as down flow or up flow filters. They are hence either supplied by inflowing water at the filter top or at the filter bottom. The vertical flow roughing filters incorporates a simple self cleaning mechanism and occupies minimal floor space when compared to horizontal flow roughing filters.

The filter material of vertical flow roughing filters is completely submerged. A water volume of about 10 cm depth usually covers the gravel and other local available materials like coconut fiber and broken burnt bricks. The top should be covered by a layer of coarse stones to shade the water and thus prevent alga growth often experienced in pretreated water exposed to the sun [12].

C. *Chemical Oxygen Demand*

The chemical oxygen demand, COD, of water as determined by this dichromate method can be considered as an approximate measure of the theoretical oxygen demand, i.e. the amount of oxygen consumed in total chemical oxidation of the organic constituents to inorganic end products. In the COD method, the results obtained are recalculated to the oxygen concentration (oxidizing agent, mg O_2 per liter). The introduction of such a parameter as COD into the analytical practice made it possible to obviate the above difficulties. The standard procedure involves boiling of a sample (2 h) in an 8 M H_2SO_4 solution, with introduction of $K_2Cr_2O_7$ and Ag_2SO_4 as catalysts and mercury salts for binding of chlorides[11]. The mechanism of oxidation of the total organic substance (Org) can be written as:

$$Cr_2O_7^{2-} + Org \rightarrow 2Cr^{3+} + CO_2 + H_2O$$
$$Ce^{4+} + Org \rightarrow Ce^{3+} + CO_2 + H_2O$$
$$Ce^{4+} + 2Cr^{3+} + H_2O \rightarrow Ce^{3+} + Cr_2O_7^{2-} + H^+$$

$$Ce^{4+} + Org \rightarrow Ce^{3+} + CO_2 + H_2O$$

III. Experimental Set Up

A. *Materials*

Configuration materials of DBD Plasma reactor are: pyrex glass, electrode alumunium (Al), copper wire, natural rubber wastewater, beaker glass, pipette and measuring cup.

B. *DBD Plasma Reactor*

Dimension and size of pyrex glass as barrier between high voltage electrode and ground electrode as shown in Fig. 2. Diameter of pyrex is 16 mm. At the center of pyrex, there is aluminum as high voltage electrode. The radius of aluminum is 3 mm.

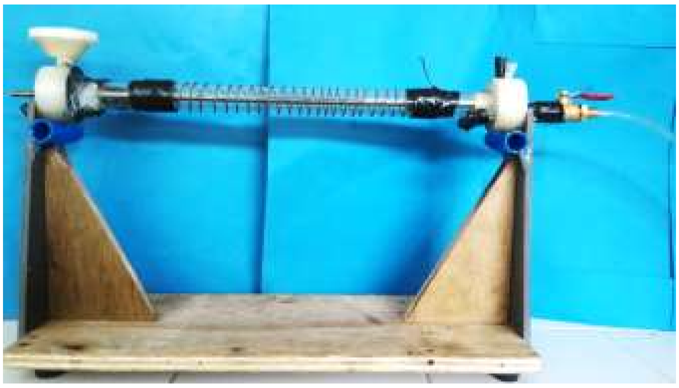


Fig 1. Geometry Plasma DBD Reactor

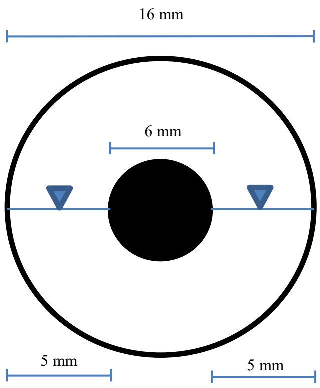


Fig 2. Geometry Plasma DBD Reactor

Fig 3. Geometry of Plasma DBD Reactor

C. *Test Circuit*

Plasma is generated from high voltage application in aluminum electrode in the pyrex tube. While the copper wire was wrapped around the pyrex tube. The test circuit for generating dielectric barrier discharge plasma as shown in Fig 4 as follow:

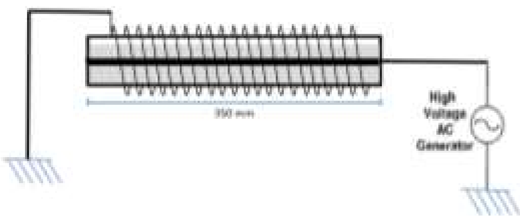


Fig 4. Test Circuit for Generating DBD Plasma

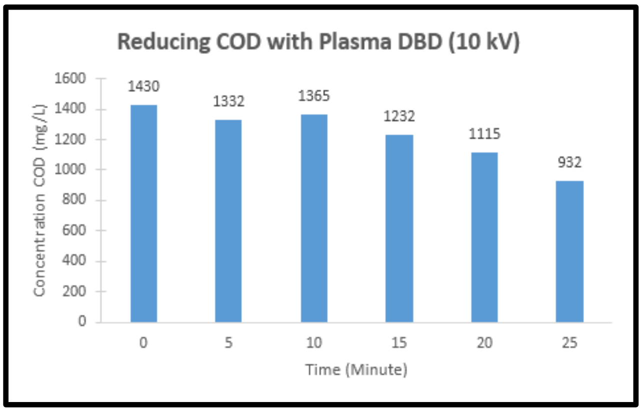
D. Spektrofotometry Test

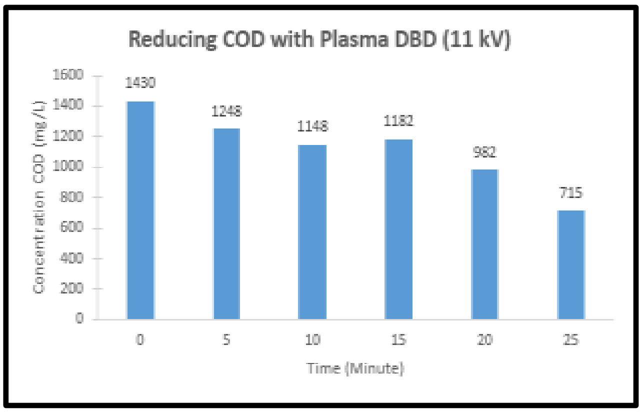
The mass concentration of oxygen equivalent to the amount of dichromate consumed by dissolved and suspended matter when a water sample is treated with that oxidant under defined conditions. Standard specifies a method for the determination of the chemical oxygen demand (COD) of wastewater following SNI 6989.73:2009 with reflux closed titrimetric. COD measurement procedure are: 2,5 ml sample of wastewater after treatment included to test tube, 1,5 ml digestion solution and 3,5 ml sulfuric acid included to tube test, covering test tube and sake to be homogeneous. Test tube included to COD reactor with temperature 150°C for 120 minutes and COD was measured absorbance at 420 nm wave spectrophotometry.

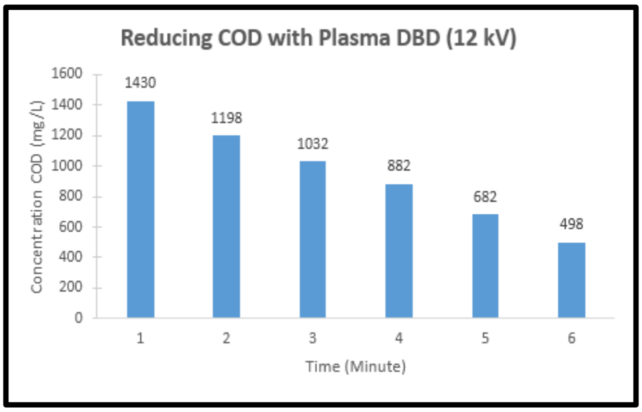
Fig 5. Spectrophotometer

IV. Results and Discussion

Result of this study quantified the responses of wastewater effluent through several key parameters of plasma Dielectric Barrier Discharge after pretreatment by vertical roughing filtration. The COD is a good indicator on quantity of chemically oxidable organic substance present in the water. In this study, the COD concentration was one parameter used to assess the removal of plasma DBD reacting pollutants from the wastewater. From previous study showed the strong reduction of the COD during plasma DBD. Fig 4 shows the evolution of COD reduction with contact time and different voltage on plasma DBD.







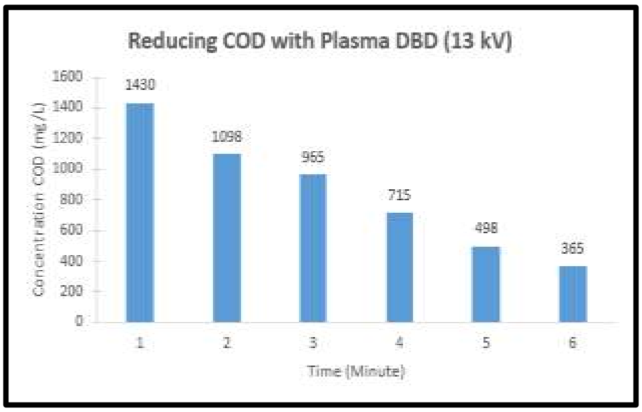
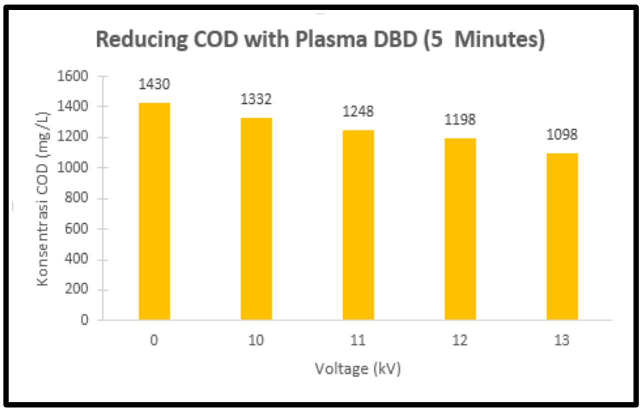


Fig 6. Graphs of Reducing Concentration of COD with Plasma DBD After Pretreatment Vertical Roughing Filtration For Time



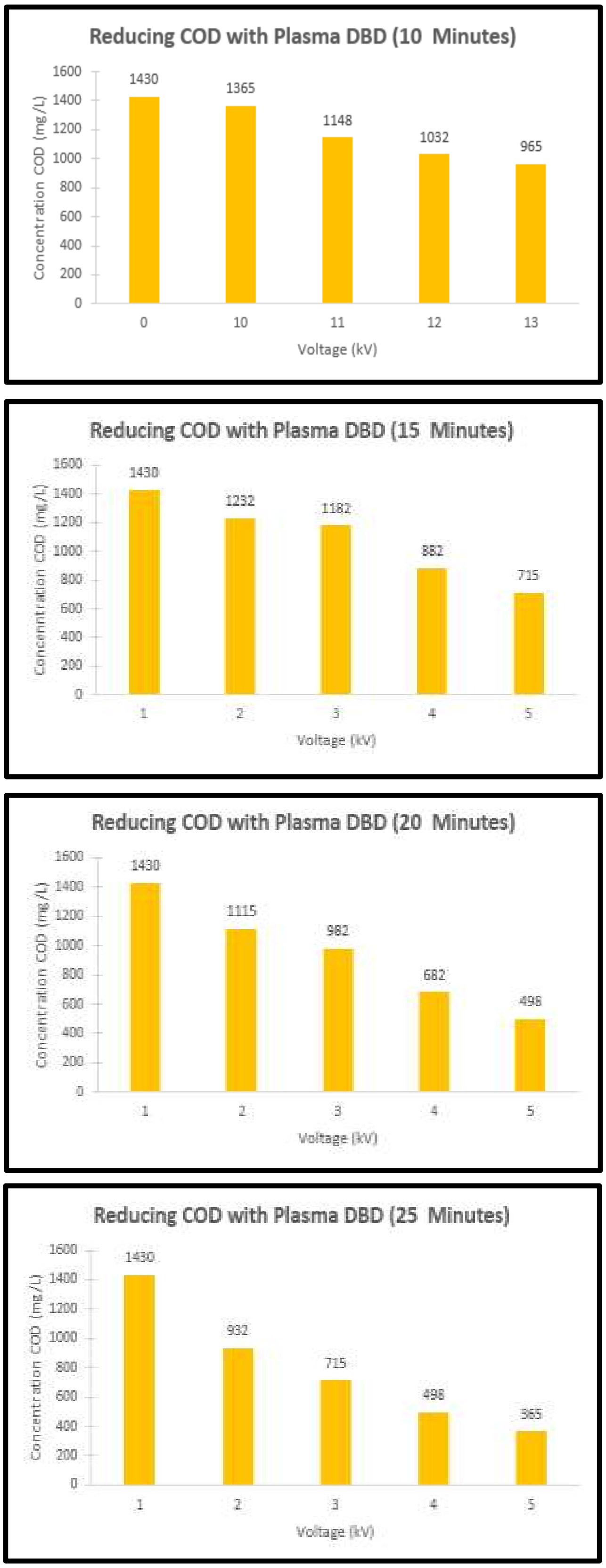


Fig 7. Graphs of Reducing Concentration of COD with Plasma DBD After Pretreatment Vertical Roughing Filtration For Voltage

Organic compounds contained in waste this is latex dissolved derived from the process of leaching raw materials rubber in a factory rubber. At the beginning, the fast increase in the COD reduction is due to the degradation of the dissolved latex compounds. This was due to termination chain chemical latex into a simple compound by species active oxidizing on plasma DBD.

Increasing voltage application to increase the number of electrons so that the collision more, consequently species active formed will rise again. Species active this is what work an important for decomposition organic compounds on waste. Long processing plasma DBD a factor important to improve the contact between wastewater with electron formed. That means more circulation increase the possibility of the collision between electrons and the establishment of more species active to degrades wastewater.

V. Conclussion

DBD Plasma was used for treating industrial wastewater. The conclusion of the research based on test results were obtained that the increase the voltage applied to the plasma reactor, causing the reduction of COD increased so that the COD concentration decreases. Likewise, the longer the duration of application of DBD plasma causes COD concentration was decreased. The combination of the higher voltage and application of time duration will result in the decrease in the concentration of COD faster.

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