Nonequilibrium Plasma Decontamination of Corn Steep Liquor for Ethanol Production: SO_2 removal and Disinfection

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Abstract: This study investigated the effect of plasma systems on corn steep liquor using (1) direct current spark discharge in liquid, (2) pulsed dielectric barrier discharge with ultrafine misting, (3) reverse vortex gliding arc, and (4) forward vortex gliding arc. Spark and DBD showed very little effect on disinfection due to high organic load in the solution. Gliding arc systems showed better disinfection and removal of SO_2 with the addition of 1% by volume of 30% H_2O_2 solution. High concentration of organic materials and minerals was hypothesized to block antimicrobial effects of plasma.

Keywords: SO_2, corn steep liquor, disinfection, decontamination, plasma

Introduction

Plasma is known to have antimicrobial effects and has been used for different applications in medicine and agriculture. Disinfection of liquids using plasma is important as it helps reduce the usage of harmful chemicals. In this study, plasma was used to infection corn steep liquor - a by-product of the wet corn milling process. Corn steep liquor contains a mixtures proteins, minerals, and micro-organism [1]. This liquid needs to be treated before use for further processing. Cold and warm plasma were used in this study to investigate their effect on disinfection and removal of SO_2.

Materials and Methods

Four plasma systems used in this study were: direct current spark discharge in liquid, pulsed dielectric barrier discharge (DBD) with ultrafine misting, reverse vortex gliding arc (RVGA), and forward vortex gliding arc (FVGA) with droplet atomizer. SO_2 concentration was measured by titration before and after plasma treatment. Treated corn steep water was plated on tryptic soy agar and incubated for analysis of bacterial load in the solution. Optical Characterization of each systems were also performed. Figure 1 below shows the setup of FVGA.

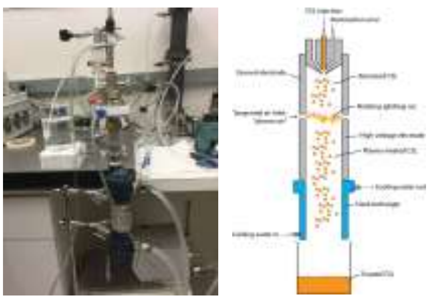

Fig. 1: FVGA system (left) setup; (right) setup schematic

Results

Spark discharge showed the least effect among four plasma systems. Treatment affected SO_2 concentration after the very first few seconds, but longer treatment time did not result in further decrease in SO_2 concentration. A low disinfection effect was observed. The result from DBD treatment was similar to that of spark discharge. Both RVGA and FVGA showed a good effect on SO_2. The concentration was found to reduce at least 35%. Disinfection was enhanced by adding a small percentage of either ethanol or H_2O_2 (Figure 2: with addition of ethanol; H_2O_2 addition produces similar result (data not shown)).

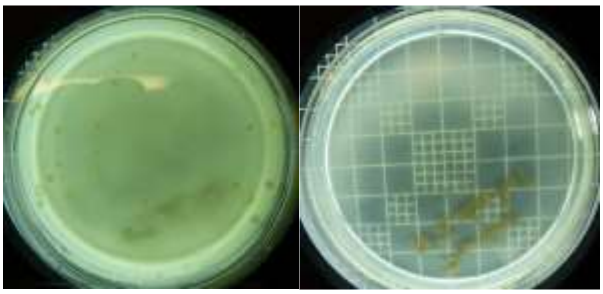

Fig.2: Sterilization results using FVGA. 10% v/v ethanol steep water before treatment (left), 10% ethanol v/v steep water after plasma treatment (right)

Discussion

Several reports claimed that a combination of reactive oxygen species and ultraviolet (UV) radiation was the primary mechanism of antimicrobial effect of plasma. In this case, the high concentration of organic materials in corn steep water would readily react with reactive species in plasma. In addition, this water absorbed the effect of UV. The effect of gliding arc systems on SO_2 can be attributed high temperature in plasma channels. H_2O_2

produced by plasma in combination with the added H_2O_2 overcame the pathogen load.

Acknowledgement

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Reference

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