BIOBUTANOL FROM FOREST RESIDUES BY SO_2-ETHANOL-WATER FRACTIONATION AND ABE FERMENTATION

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Abstract

A process for production of biobutanol from forest residues, such as branches, tree tops and stump wood, is presented. It utilizes SO_2-ethanol-water (SEW) fractionation, and fermentation of the sugars obtained by combining the conditioned spent fractionation liquid and enzymatically hydrolysed cellulosic fibres. This Biorefinery concept is called AVAP^{TM} by American Process Inc.

It is demonstrated that the SEW technology using 50% (w/w) ethanol-water containing 12% (w/w) SO_2 efficiently fractionates both softwood (SW) and hardwood (HW) biomass in only 30 min at 150ºC temperature. Hemicellulose sugars are dissolved in high yield (80%) in the spent fractionation liquor and of these up to 50% are in monomeric form. Sugar degradation products are not formed in significant quantities due to the short treatment time. Delignification is efficient, being 89% for HW biomass and 64% for SW biomass after only 20 min treatment.

The pulp fibers after SEW fractionation are washed to allow for high sugars recovery. The wash liquor is added to the drained spent SEW liquor and the mixture is then evaporated under low pressure to recover the fractionation chemicals. Ethanol removal is almost complete after vaporizing 2/3rd of the weight while most of the residual SO_2 is removed during subsequent steam stripping. Neutralization by liming with $Ca(OH)_2$ is then employed to bring the solution to a pH level suitable for fermentation. The liquor is then catalytically oxidized to convert any residual sulfite ions to sulfate. Finally, the liquor is treated with resins to further remove lignin.

Cellulose in the fibers is enzymatically hydrolyzed to glucose. Glucose yields up to 95% are achieved for HW cellulosic residues utilizing a commercial enzyme mixture at 3% enzyme dosage on substrate whereas the SW residues are shown to require higher enzyme dosages. The differences in enzymatic digestibility are partially explained by the chemical characteristics of these feed stocks.

Fermentation of the combined sugar stream has been successfully carried out using a patented fermentation column technology where wood pulp is used as cell immobilization material for the Clostridium acetobutylicum strain. ABE (Acetone, Butanol and Ethanol) solvent mixtures were produced at a productivity of almost 5 g/L/h and total yield of 0.27 g/g sugars.

Preliminary techno-economics for a 470 ktonne/year of biomass (dry basis) Biorefinery producing 61 ktonne/year of butanol and other products indicates that this concept is profitable at industrial scale.