Pretreatment to lignocellulosic substrate by fluidized foam bed column

Ganesh A. Bathe[1*] and Parvez A.A. Ansari[2]

[1,2]*Chemical Engineering Department, University Institute of Chemical Technology, KBC North Maharashtra University, Post box 80, Jalgaon-425001, India.*

ganeshbathe@yahoo.com, parvezansarichem@gmail.com

Abstract:

In the current work, lignocellulosic material was pretreated in fluidized foam bed column (FFBC) to increase the susceptibility. Lignocellulosic solid substrate is a natural polymer of cellulose, hemicelluloses and lignin which bound together in a complex structure. Before feeding this lignocellulosic substrate to solid state fermenter (SSF), it should be pretreated to increase the enzymatic action, swelling the pores of substrate and to increase the surface area. The pretreatment generally enhances the bio-digestibility of the lignocellulosic material. Various pretreatment methods for solid substrate are available in literature which shows their own advantages and disadvantages. In the current work, new concept of FFBC was used for pretreatment of soybean straw. Treated and untreated results of substrate were analyzed by SEM and XRD.

Keywords: *lignocellulosic material, fluidized foam bed column, pretreatment, Crystallinity, Solid state fermentation*

1. Introduction

Few physicochemical pretreatment methods were tried and compared in this paper along with new concept of FFBC. Lignocellulose is a complex polymeric material containing cellulose (40-50% on weight basis), hemicelluloses (25-35% on weight basis) and lignin (15-20% on weight basis) [1-2]. Lignin generally acts as a binder for cellulose and hemicellulose. Lignin is heavily cross-linked and highly branched polymer [3]. Various traditional substrate pretreatment methods are available and each method having its own merits and demerits [4-6]. The main objective of pretreatment processes, is to minimize lignin resistance and to make cellulose easily available for enzymatic attack. The absence or improper pretreatment leads to poor biomass growth and subsequently low product yield in solid state fermentation (SSF). Lignocellulosic material is firstly treated mechanically (*i.e.* by cutting and milling operations) which will reduce the size of the lignocellulosic material. This size reduction will be increasing the surface area of lignocellulosic material. Again, these material is then pretreated by another secondary method (*i.e.* by Physico-chemical / Chemical / biological methods) to enhance the digestibility. Due to secondary pretreatment pore size of the substrate increases and reduce the crystallinity of cellulose [7]. In the current work, new application of foam in the pretreatment of lignocellulosic material is checked and compared with other methods. Foam presence is desirable in few manufacturing process and in the same manner undesirable for few process [8]. It was found that the non-ionic surfactant, Tween-20 help in lignin removal during pretreatment [9]. Here in this work, Tween- 20 surfactant was used to create the foam and to pretreat the agro-waste in FBBC.

2. Materials and Methods

2.1 *Materials*

Locally available agro-waste of soybean straw was collected and washed with water to remove unwanted particles. After that, this lignocellulosic material was crushed and ground to pass through 85 mesh (BSS standard) sieves.

2.2 Experimental set-up

20 g of soybean straw material was faded to FFBC as shown in fig.1. Surfactant, Tween 20 was used as a foaming agent in this process. Then, this lignocellulosic material was thermally treated for 20 min by following ways independently.

(I) Treated with boiled distilled water at atm. pressure, 100 ^{0}C

(II) Treated with steam in fluidized bed at atm. pressure, 100 ^{0}C

(III)Treated inside fluidized foam bed at atm. pressure, 100 ^{0}C

(IV)Untreated samples of agro-waste straw as control

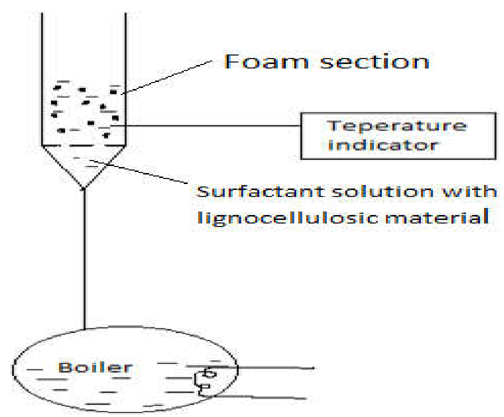


Fig.1 Fluidized foam bed column

After treatment condensed water was removed by filtration. Finally, the substrate mixture was gradually allowed to cool down to ambient temperature and then dried in a convection oven.

3. *Analysis of lignocellulosic material.*

3.1 Field Emission Scanning Electron Microscope (FE-SEM)

FE-SEM imaging was done by a Hitachi S4800 Type II scanning microscope. Samples were mounted onto aluminum pin stubs and sputter coated with gold. Images were acquired as TIFF format files.

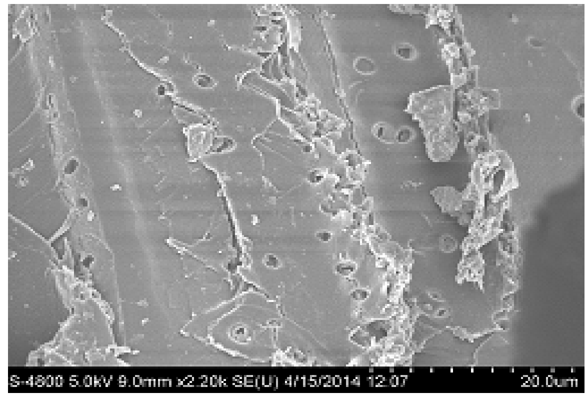
3.2 X –ray Diffraction analysis (XRD)

XRD patterns were collected on a Bruker (D8 Advance) diffractometer (40 kV, 40mA) equipped with a Ni filter, using Cu Kα radiation (λ = 1.54 A^0). Scans were performed from 5^0 to 80^0 with 0.03^0 increments at 0.5 s per step.

4. Results and Discussion

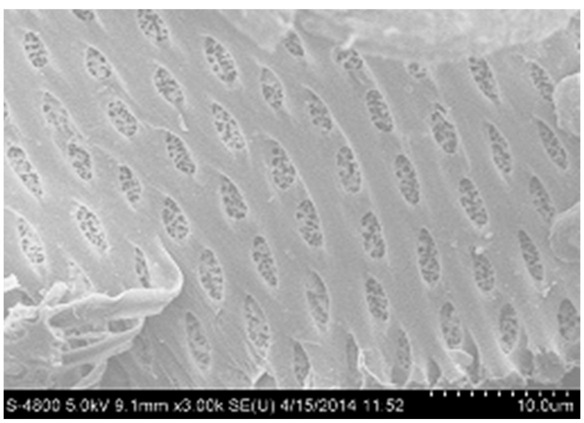
4.1 FE-SEM analysis

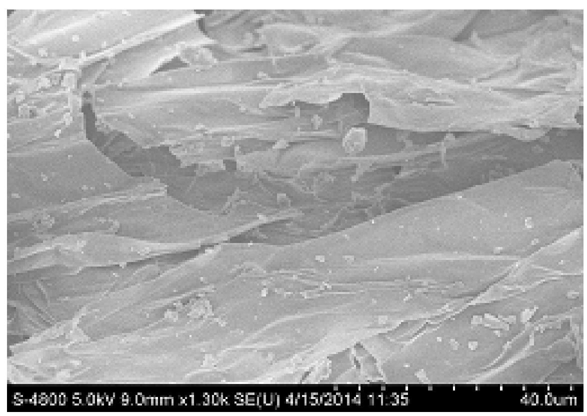
The surface morphology of untreated and treated soybean straw was analysed under FE-SEM. Figure 2 shows the SEM images of untreated and treated soybean straw by various methods. Pretreated substrate shows swollen and porous structure. Substrate material treated inside FFBC shows little improvement in porous structure of the substrate as surfactant helps in removing lignin. Various surfactants and process conditions can be varied to optimize the best result.



(a) Boiled Treatment

(b) Steam treatment





(c) Foam Treatment

(d) Without Treatment

Figure 2. FE-SEM of soybean straw

4.2 X –ray Diffraction analysis (XRD)

XRD patterns of the pretreated and untreated soybean straw are shown in figure 3. XRD analysis observed a reduction of crystallinity in pretreated soybean straw when compared with untreated soybean straw. Porosity of the biomass increases when the crystallinity of the lignocellulosic material reduces. [10-12]. The presence of lignin and hemicelluloses in soybean straw gives resistance to change in crystalline structure. XRD results for FBBC was comparatively in the same range with other methods.

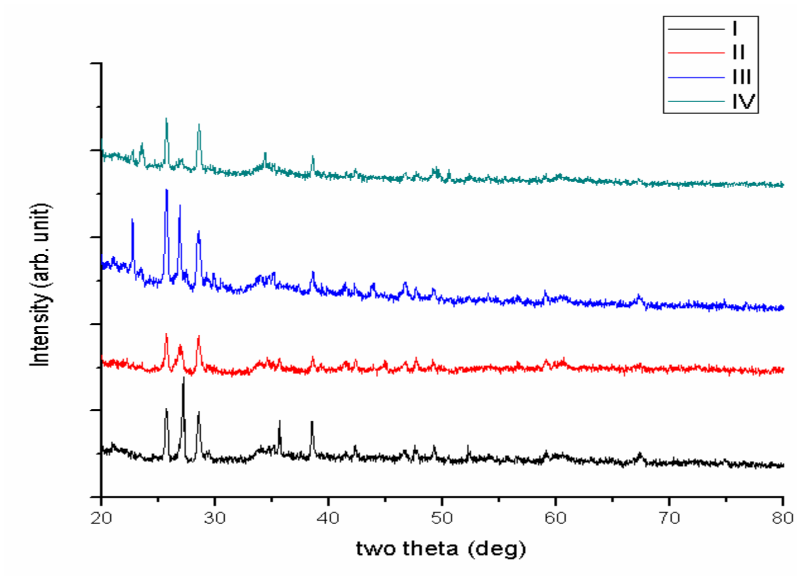


Figure 3. XRD of soybean straw

In SSF, process cost can be reduced, if pretreatment method is cost effective. FFBC is a new approach for pretreatment some other surfactants with optimized process parameters can also be tried and find the applicability of this new method to pretreatment.

5.Conclusions

The main objective of pretreatment is to increase surface area, to increase the amorphous nature of cellulose, to increase the porosity of the substrate and to remove hemicellulose and lignin. Several studies have been conducted on lignocellulosic pretreatment [1-7;9-14]. In the current study, new approach of FFBC was introduce for the pretreatment of lignocellulosic material. Though comparative performance FFBC was not that much efficient if compared with other methods mentioned above. But, constant work on FFBC can provide new Cost effectives technology for the pretreatment of lignocellulosic material.

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