Biochemical conversion of rice straw into bioethanol - an exploratory investigation

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INTRODUCTION

- Growing energy demands in transportation, industrial and other sectors with a simultaneous reduction of green house gas emissions.

INTRODUCTION

- Solar produced ecofriendly cheap biomass (lignocellulosics,150 billion ton/annum) - renewable resource for biofuels - an alternative fuel or oxygenate additive to the fossil fuels

INTRODUCTION

- Plants contain 6 x 10^{11} tones of hemicellulose and about 3 x 10^{10} tonnes are photosynthesized annually. Hemicelluloses are low molecular weight compounds with DPn 200.

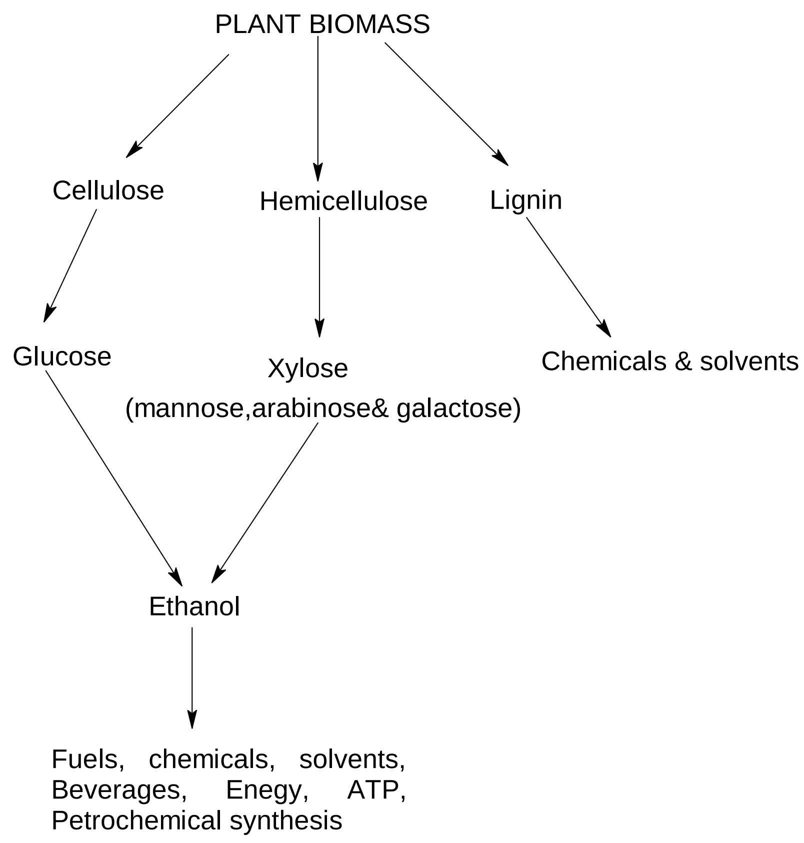
WHY BIOETANOL FROM BIOMASS?

- i) biomasses are geographically more evenly distributed than fossil fuels &hence the energy sourceswill be domestic and provide security of supply,
- ii) lignocellulosic wastes minimize the potential conflict between land use for food (and feed) and energy feedstock production,

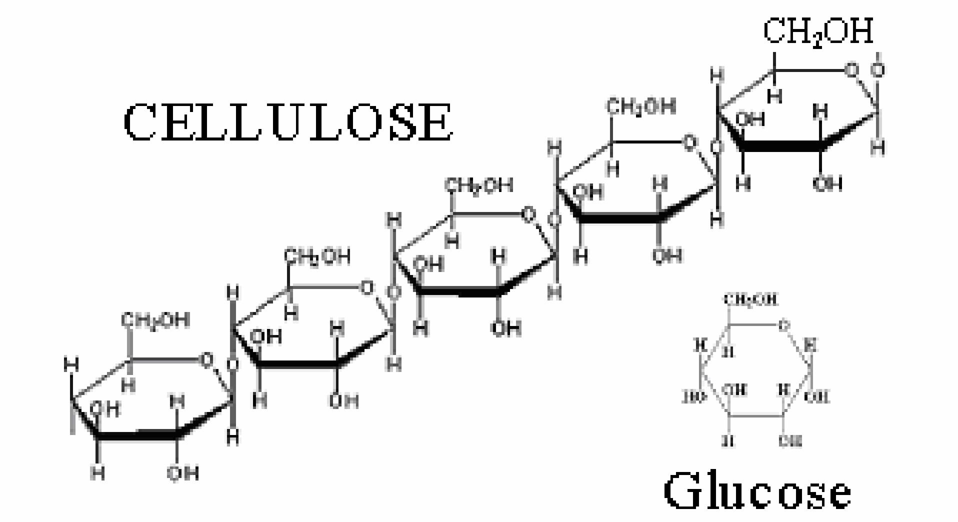
WHY BIOETHANOL FROM BIOMASS?

- iii) the raw material is less expensive than conventional agricultural feedstock,
- iv) it (ex.switch grass) can also be produced with lower input of fertilizers, pesticides, and energy.
- v) biofuels from biomass- economic, environmental friendly (low emission of green house gas)
- vi) it can also provide employment in rural areas

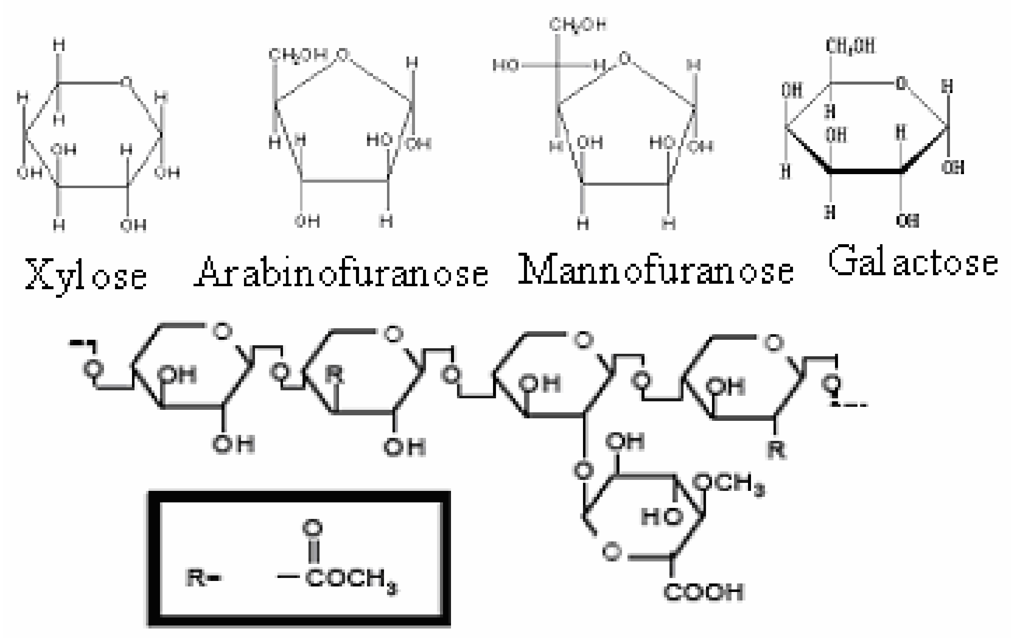
PLANT BIOMASS



CELLULOSE

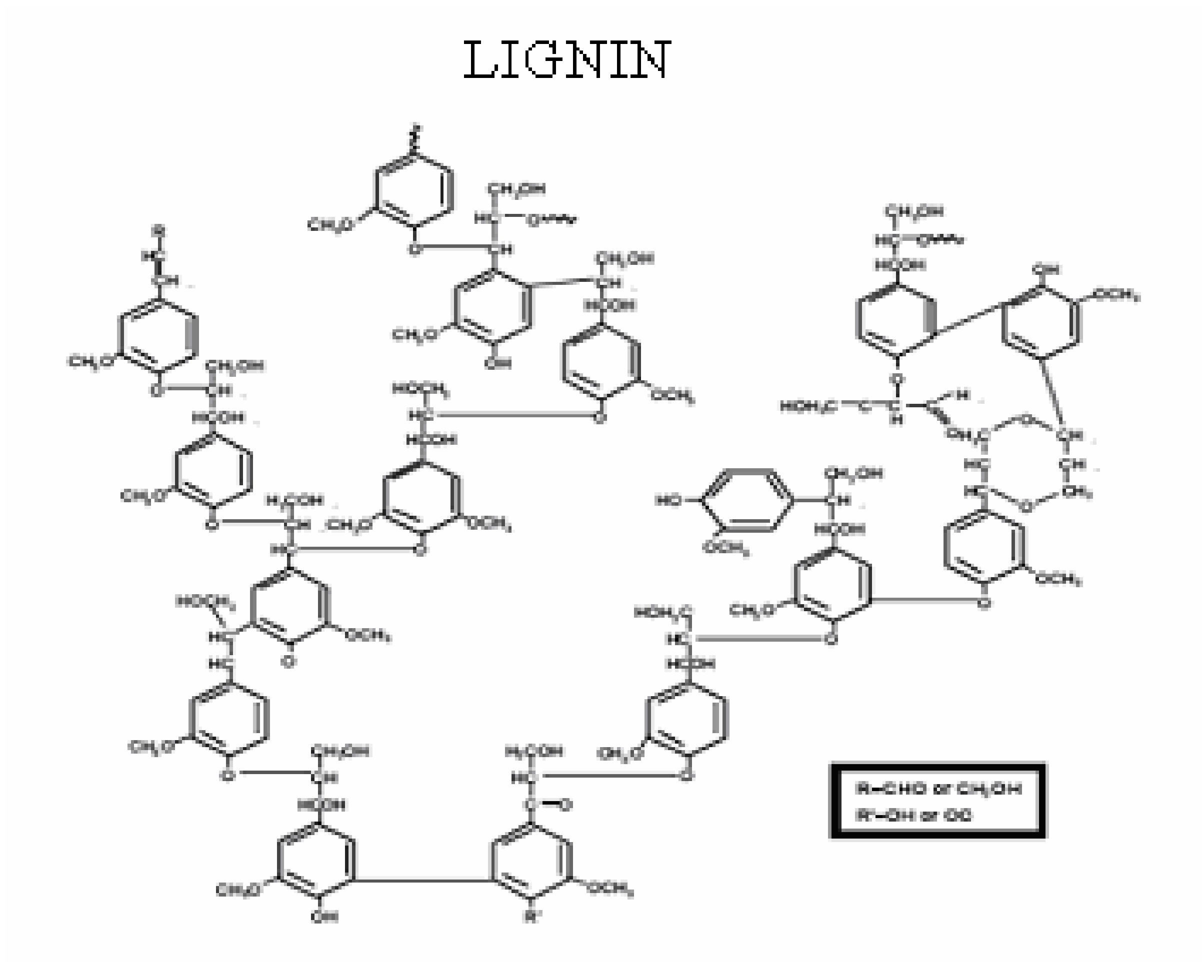


HEMI-CELLULOSE



HEMI-CELLULOSE

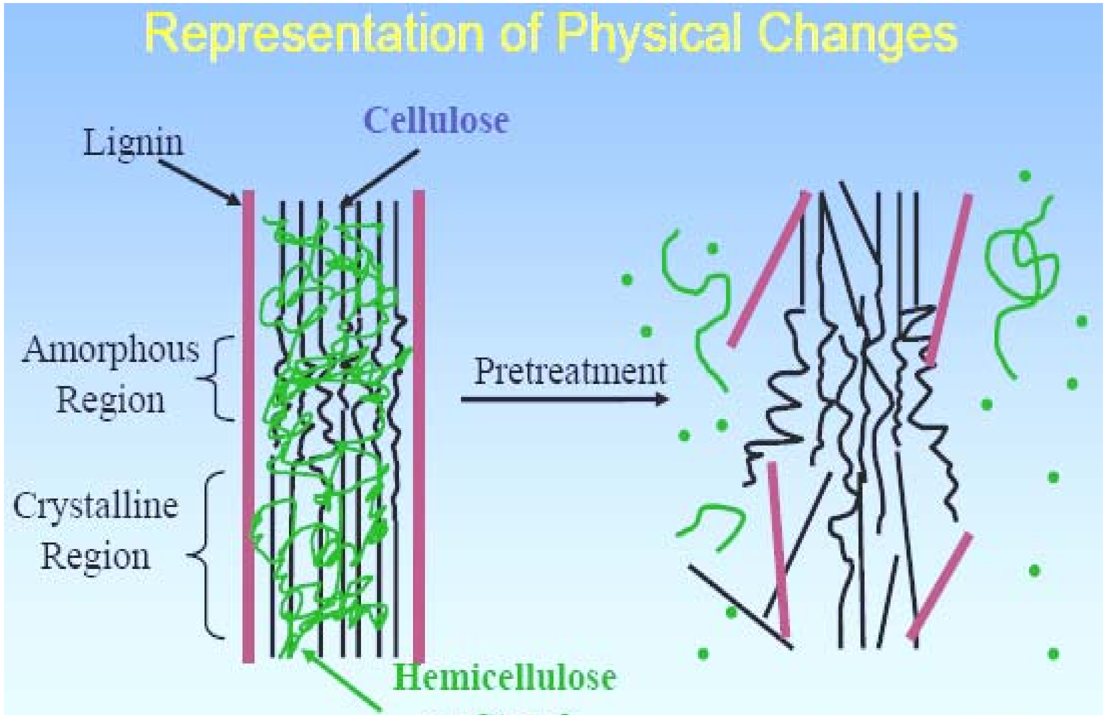
LIGNIN



PRETREATMENT

- Saccharification of biomass- affected by porosity, fiber crystallinity, lignin and hemicellulose contents
- Lignin acts as a physical barrier should be removed to facilitate saccharification
- Pretreatment- mechanical, physical, chemical or biological- make cellulose to be more accessible to enzymes via removal of lignin and hemicellulose, reduction of cellulose crystallinity, and increase in porosity.

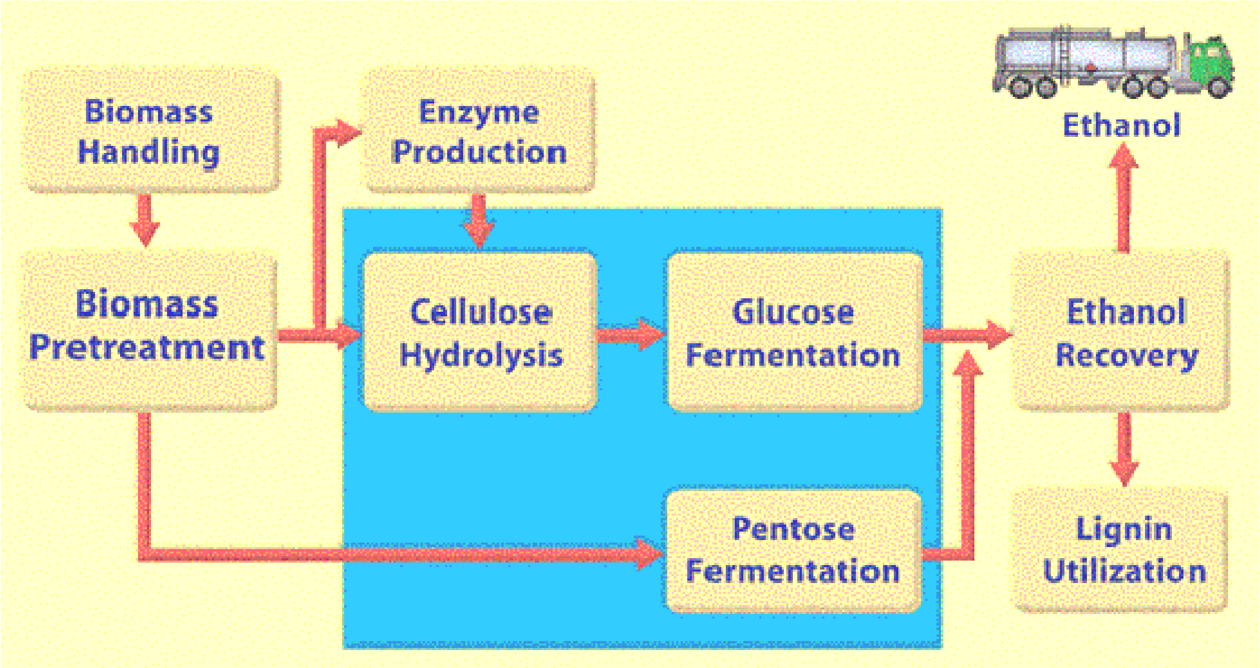
SCHEMATIC REPRESENTATION OF PRETREATMENT



RICE STRAW-COMPOSITION & PRODUCTION

- Rice straw(cellulose: 37%, hemicell-ulose:24% &lignin(14%)-an abundant biomass. Production 731 million tones/annum - produce about 205 billion litre bioethanol .
- Wheat and rice straw together : 200 million tonnes/ annum in India
- 1 kg rice straw has 350 g of cellulose which depends upon variety and the geographical location. This can theoret-ically yield 220 g /283 ml ethanol.

SCHEMATIC DIAGRAM FOR ETHANOL PRODCUTION FROM BIOMASS



SACCHARIFICATION OF CELLULOSE: METHODS

- Cellulose to ethanol by either SSF or SHFprocess. SSF is more favored because of its low potential costs
- Drawback of SSF : Different optimum temperatures for hydrolyzing enzymes and fermenting microorganisms. SHF method is followed here.

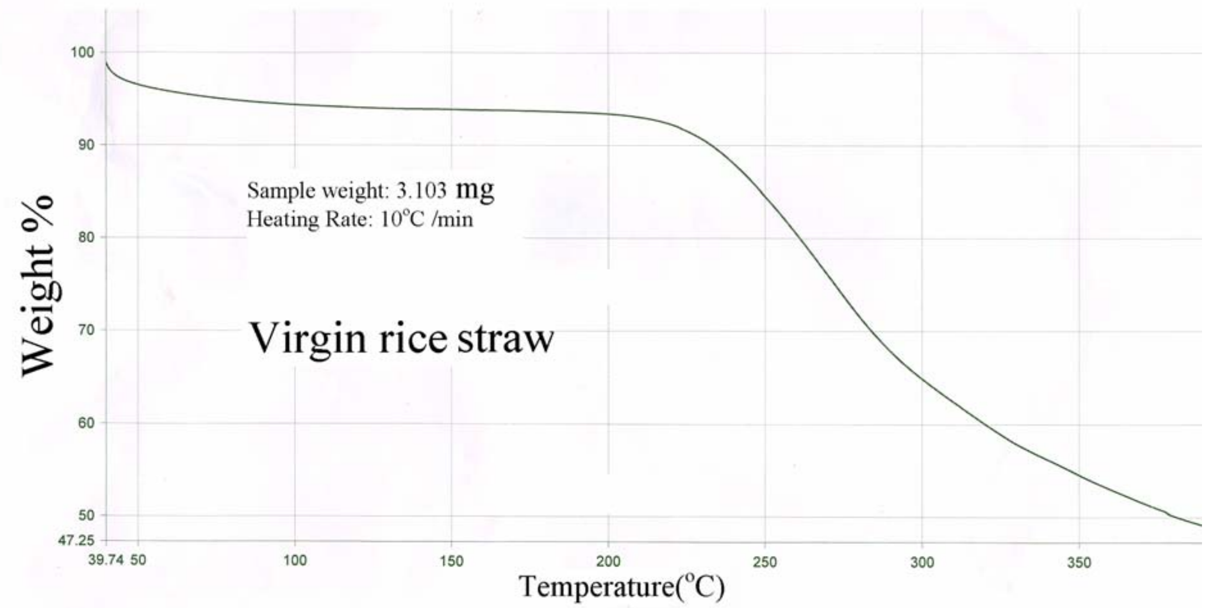
PRETREATMENT OF RICE STRAW

- Rice straw(Collected locally) washed and desoiled by froth-floatation in water, air dried & chopped into small pieces. Partially delignified using 4 % NH_4OH at 15 bar &120^oC for 20 min in an autoclave at a volume ratio of 5:4 Washed with hot water repeatedly till free from alkali.
- NH_4OH treated rice straw is dipped in 1% sulphuric acid and autoclaved at 120^oC for 15 min at 15 bar

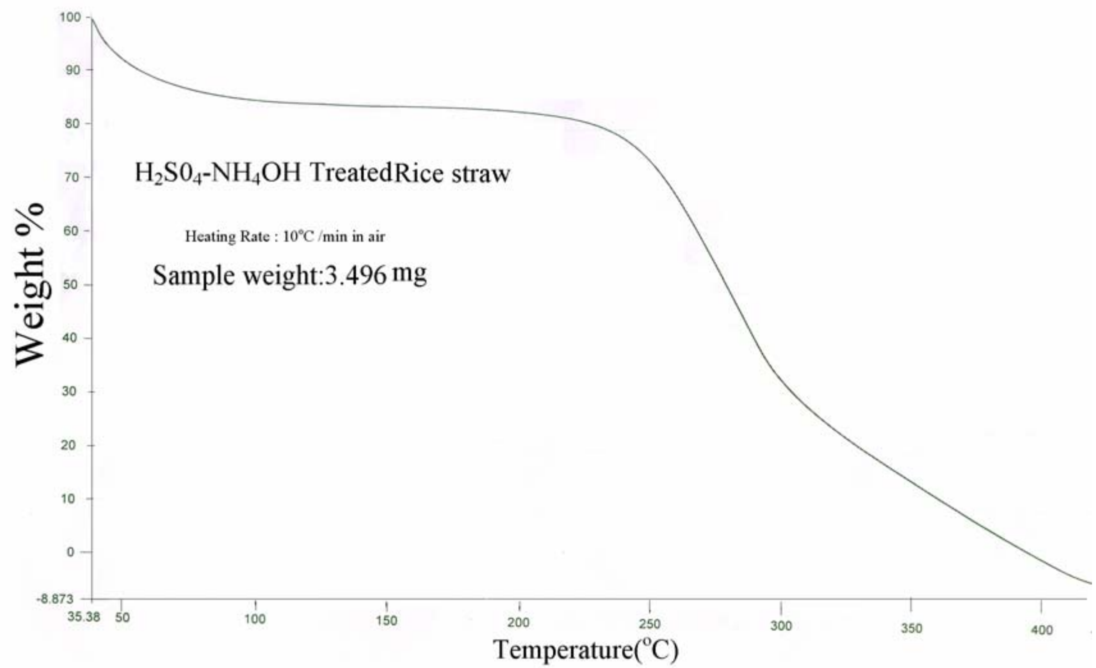
RICE STRAW SACCHARIFICATION

- Done by using acid or enzyme catalyst or a combination of these two.
- Acid hydrolysis: 3 % sulfuric acid solun.
- Enzyme hydrolysis : Cellulase (liquid) enzyme (ROSSARI BIOTECH) optimum pH range :4.5-6 in 2M citrate buffer at 45oC over a period of 24 hrs.

TG Trace for virgin rice straw



TG Trace for NH_4OH treated rice straw



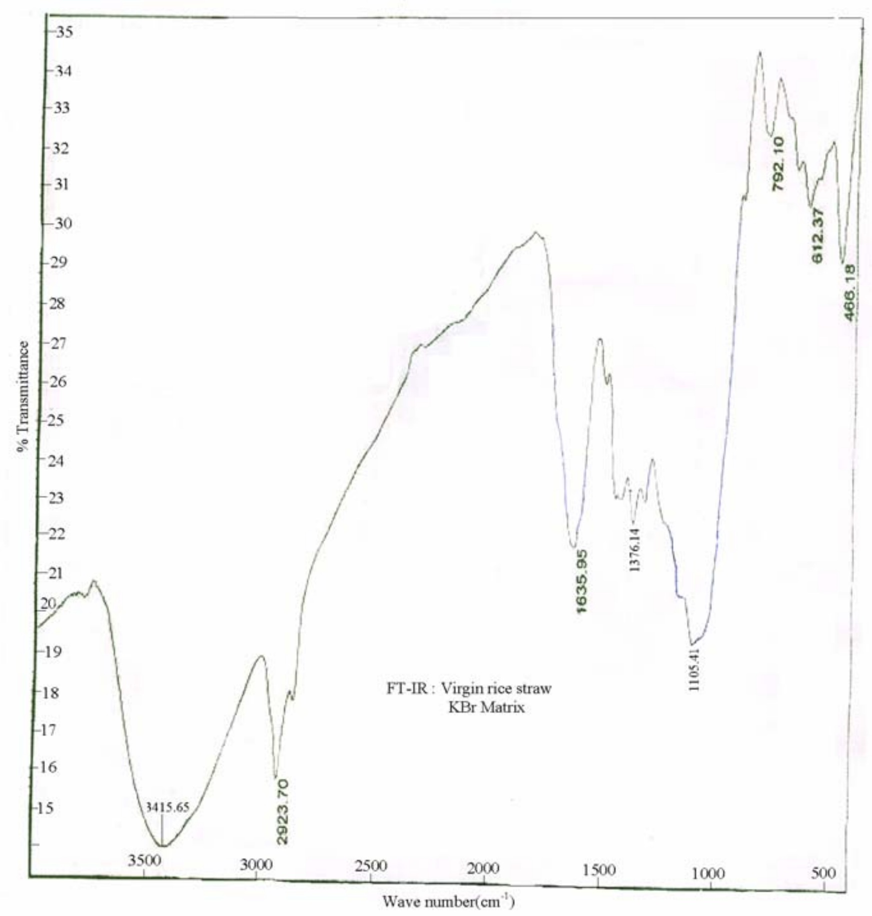
TG Data for Rice straw

Rice straw sample%	Weight loss at(°C) 100	250	350	%Residue (400°C)
Desoiled (virgin)	6	14	46	48
Acid treated	10	18	69	21
Acid - NH4OH treated	15	28	82	Nil

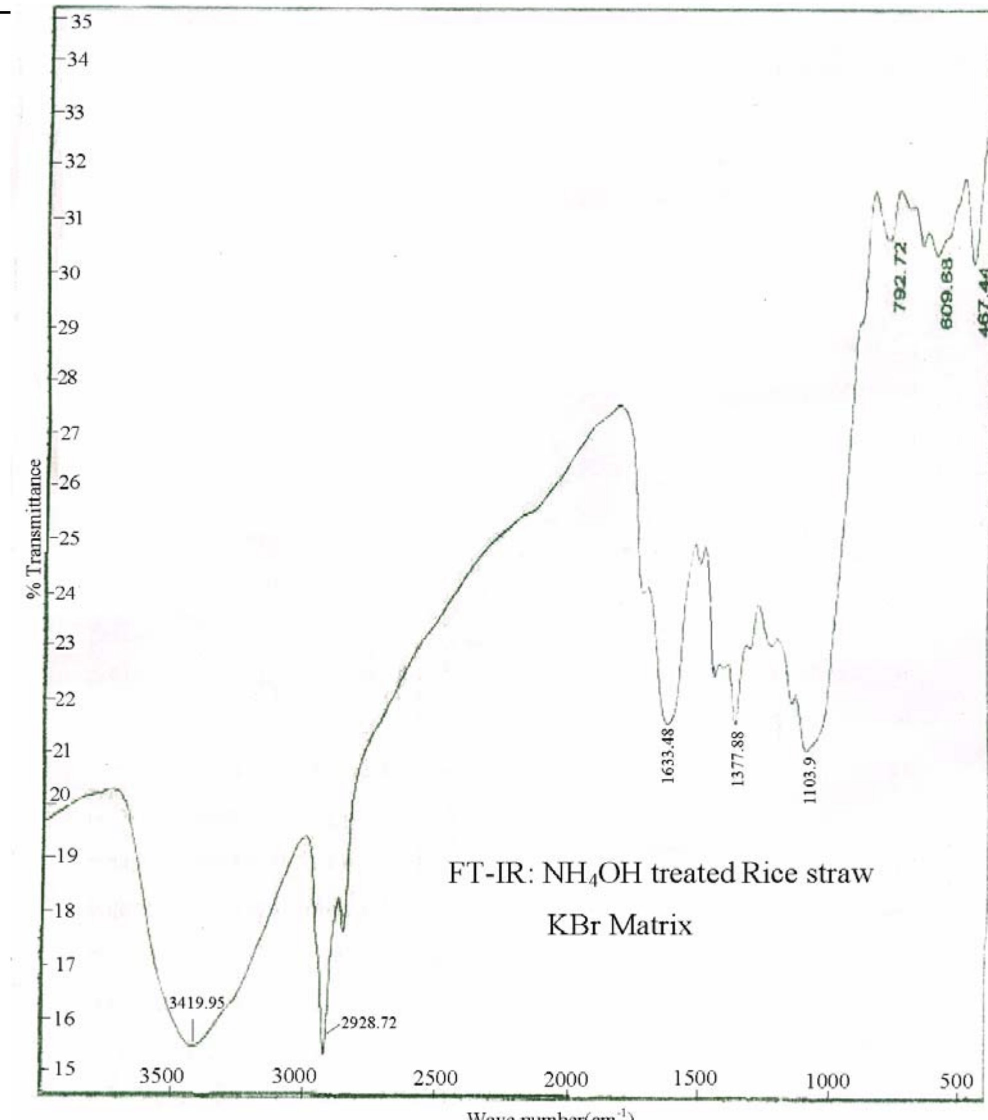
Sugar and ethanol yields per 25 g of desoiled rice straw

Saccharification method	Sugar yield (g) / 25 g of rice straw		Ethanol yield (g) from 25g of rice straw	
	Theo	Expt	Theo	Expt
Ethanol yield (g) from 25g of rice straw	11	6.5	5.6	3.2
Acid-Enzyme hydrolysis	11	9.5	5.6	4.8
Enzyme hydrolysis	11	8.3	5.6	4.2

FT-IR Spectrum for virgin rice straw



FT-IR Spectrum for NH_4OH treated rice straw



FT-IR SPECTRUM

- The reductions in intensity of the peak at 1540 cm^{-1} and reduction in $I_{1634cm-1}$ /$I_{2924cm-1}$ intensity ratio from 1.2(virgin) to 0.766 in NH4OH treated rice straw are attributed to delignification.

FT-IR Spectral data

Frequency (cm-1)	Assignment
3416	O-H (stretching)
2924	C-H (stretching)
1735	O=C-O (stretching)
1635	C=O (stretching)
1540	C=C (aromatic ring stretching)
1410	CH2 (bending)
1310-1360	C-C and C-O (skeletal vibrations.)
1377	C-H (bending)
1200	C-O (stretching in pyronose ring)
1170	C-O(antisymmetric bridge stretching)
1105	C-OH (skeletal vibrations)
1080	C-O-C(pyranose ring skeletal vibration)
1030	C-O (C-6 skeletal vibrations)
990	C-O(sec.alcohols skeletal vibration

CONCLUSIONS

- saccharification - more effective in the combined successive acid and enzyme catalysis. The sugar and ethanol yields are 10-12% more in this method compared to those with liquid enzymatic saccharification-cum- fermentation.

CONCLUSION

- This is due to better accessibility of the cellulose to cellulase enzyme by the removal of hemicellulose and lignin. Substantiated by its faster thermal degradation in the temperature range 200-400^{o}C and nearly complete degradation at 400^{o} C in the former case.

ACKNOWLEDGEMENT

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