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Effect of Methanol Addition on Properties and Aging Reaction Mechanism of Bio-oil during Storage
-Research and Development of Biomass Conversion Technologies

Ronghou Liu刘荣厚
Professor with tenure, Director，PhD
Biomass Energy Engineering Research Centre
School of Agriculture and Biology
Shanghai Jiao Tong University
800 Dongchuan Road, Minhang District
Shanghai 200240，P.R.China
Tel: 0086 21-34205744
0086 13681602458
Email: liurhou@sjtu.edu.cn

There are6 main parts

1. Introduction to Shanghai JiaoTong University(SJTU)
2. Biomass fast pyrolysis for bio-oil production
3. Biochar application for soil amendment
4. Bioethanol
5. Biogas technology
7. Conclusion

1.Shanghai JiaoTong University(SJTU)

- Established in 1896
- There are 20 schools, including school of Agriculture and Biology, School of Mechanical and Power Engineering, School of Environment Engineering, etc.
- Students:44020; Teachers:2851
- Area of campus: about 333 ha.

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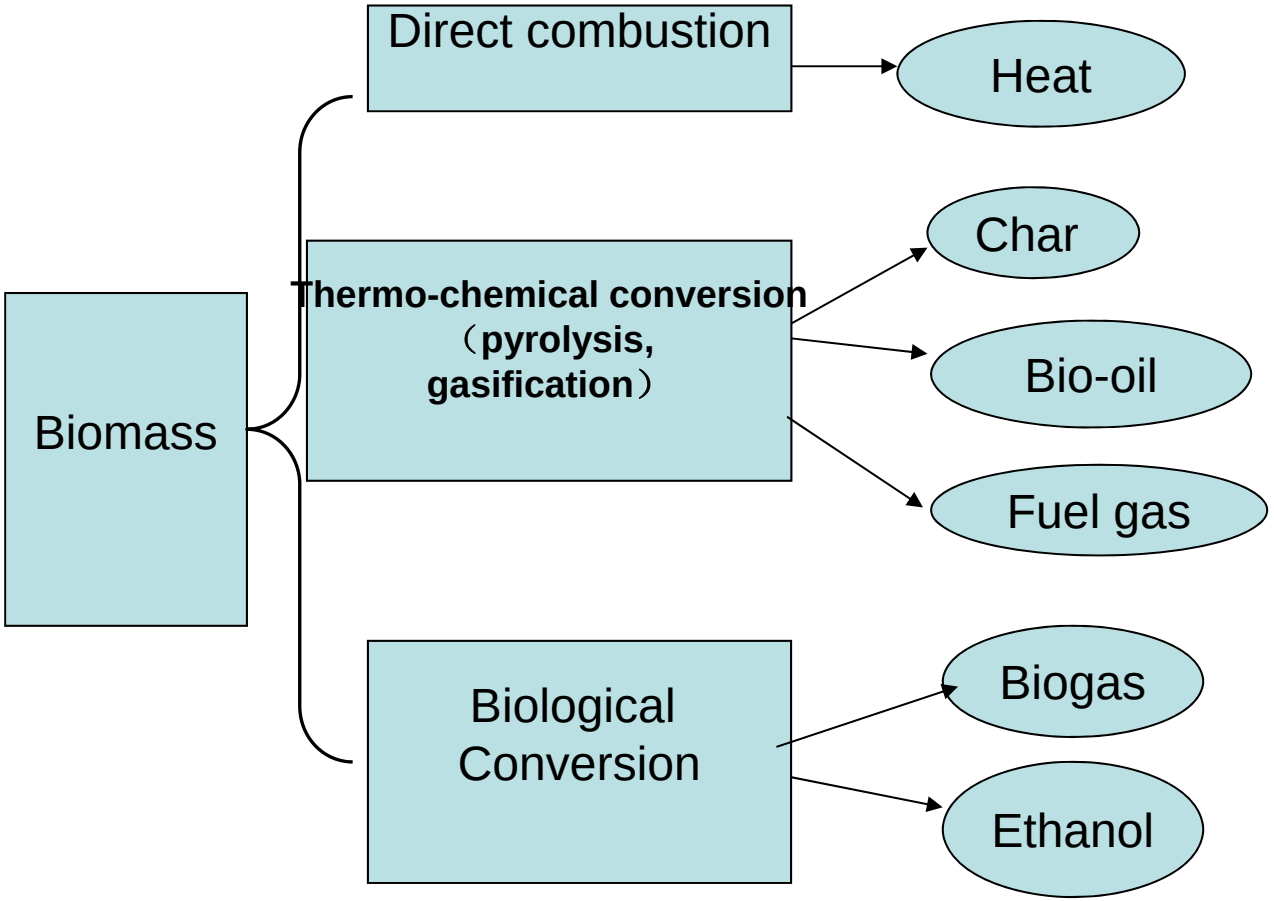
上海交通大学农业与生物学院
生物质能工程研究中心

School of Agriculture and Biology (SJTU)

Biomass Energy Engineering Research Centre,

School of Agriculture and Biology , Shanghai JiaoTong University has a lot of experiences in the field of biomass energy and environment, including characterization of biomass, biomass pyrolysis, biogas ,biochar, gasification, bioethanol, etc.

Biomass energy conversion technologies



2.Biomas fast pyrolysis for bio-oil production
Mechanism of biomass pyrolysis

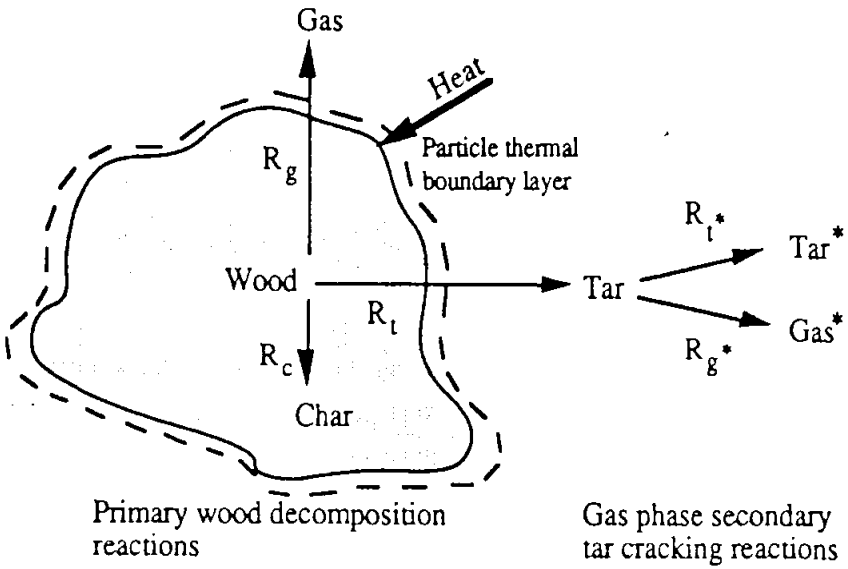
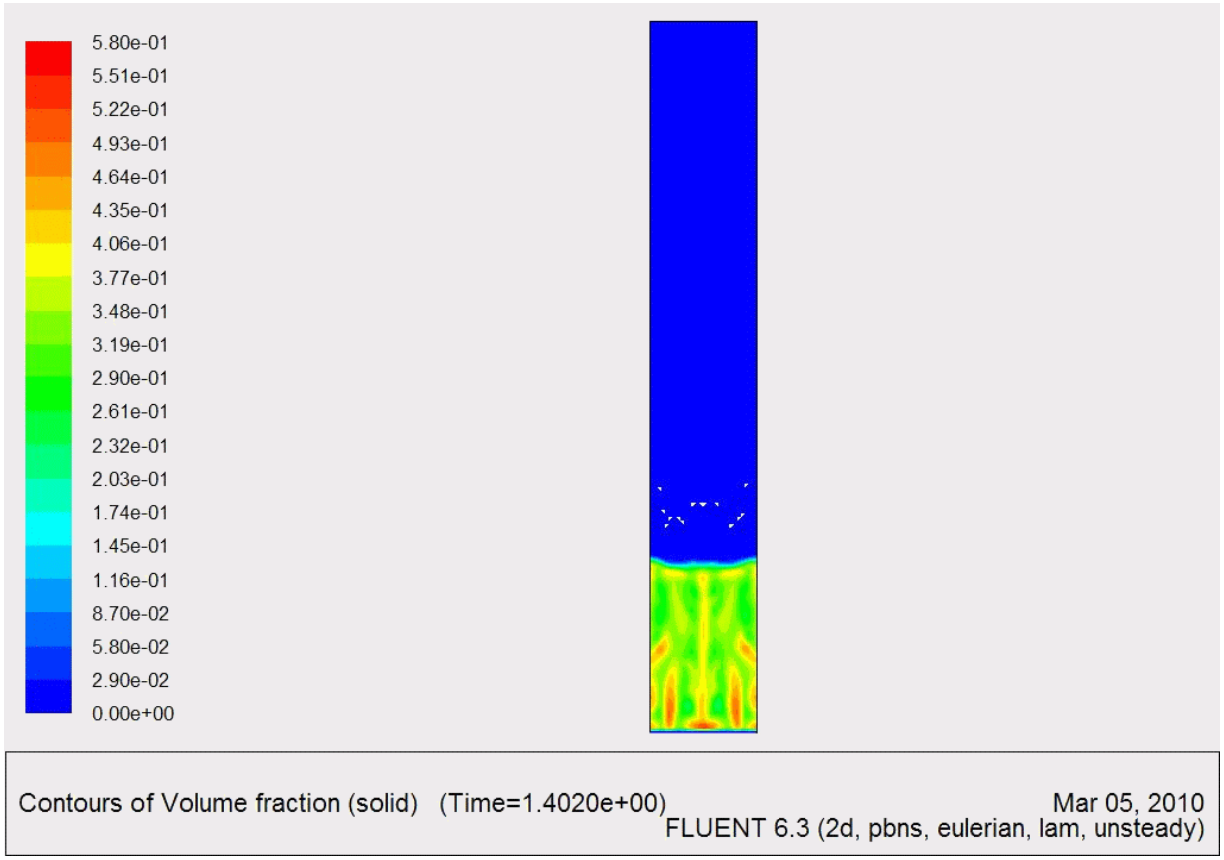


Fig.1 Sketch of a Decomposing Wood Particle Including the Reaction Paths Involved

If the pyrolysis conditions are proper, 100kg biomass can produce 60 kg bio-oil.



Result: when time is 4 s, the fluidization of sand is best

Simulation of sand in fluidized bed reactor

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Fluidized bed reactor for biomass fast pyrolysis for bio-oil production developed by Shanghai JiaoTong University

- Biomass throughput:1-5 kg/h;
- Reactor Temperature:400-600°C
- Biomass particle size:1-2mm

Bio-oil from stalk by fast pyrolysis (National Natural Science Fund of China, Coordinated by Prof.Liu Ronghou, Biomass Energy Lab. SJTU
秸秆快速热裂解产生的生物油(刘荣厚教授主持完成了国家自然科学基金项目,上海交通大学农业与生物学院生物质能实验室)

【Products yields】：

【产物产率】：

- Bio-oil ： 60wt%

  生物油：60wt%

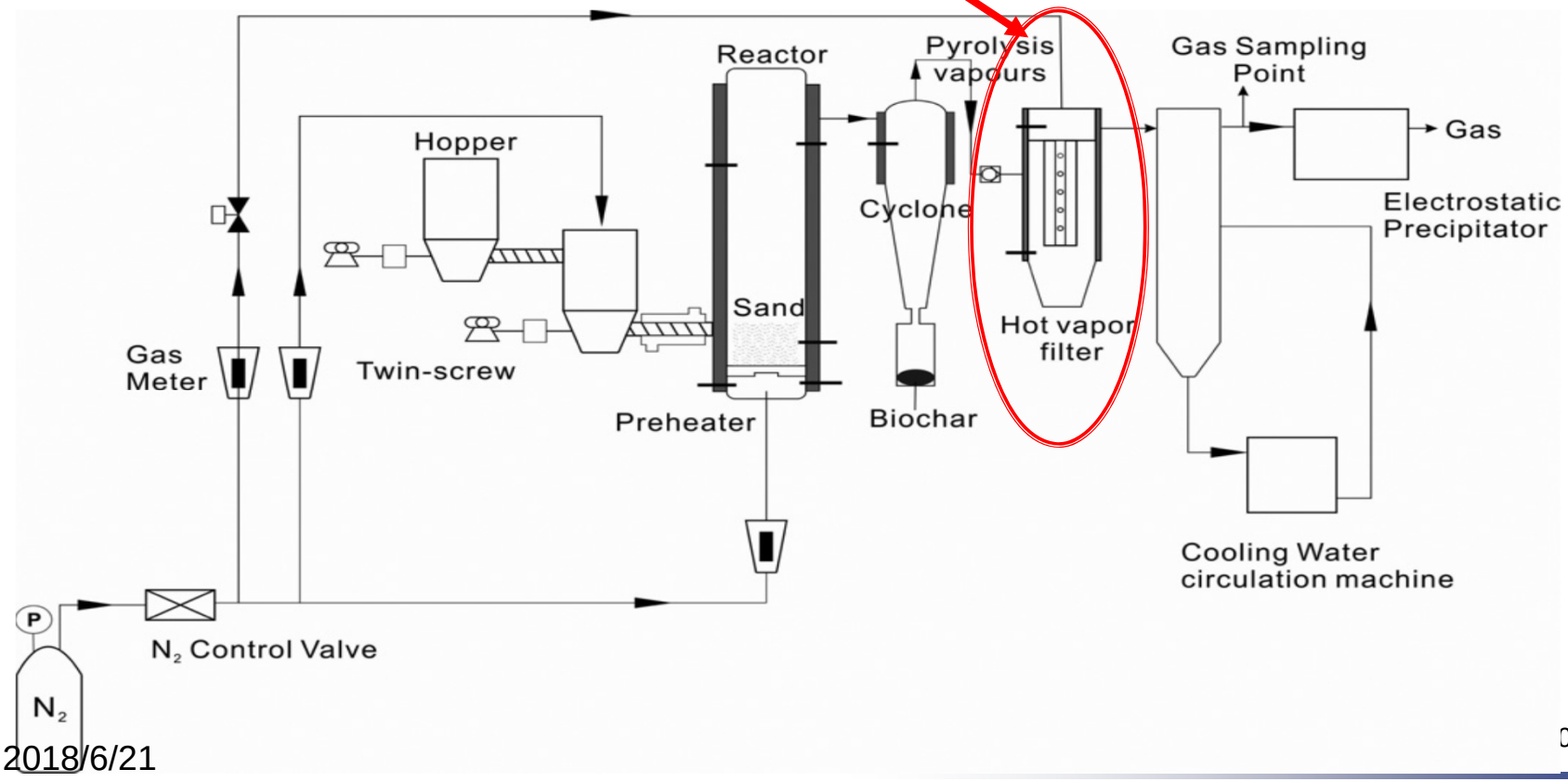
- Non-condensible gases：30wt%

  可燃气： 30wt%

- Char ： 10wt%

  木炭： 10wt%

*Effect of hot vapor filtration on the characterization of bio-oil from rice husks with fast pyrolysis in a fluidized-bed reactor



Yield and physicochemical properties of bio-oil at condenser

Yield and physicochemical properties of the bio-oil at the condenser and the EP.

	C_1[c]	C_2[c]	F_1[c]	F_2[c]
Water content(wt.%)	64.41 ± 0.16	10.77 ± 0.10	75.09 ± 0.42	9.19 ± 0.08
Yield of bio-oil (wt.%)	57.3	42.7	60.5	39.5
Ratio of collected water content of oil[a]	88.9	11.1	92.7	7.3
C (wt.%)	17.07	60.95	10.67	66.56
H (wt.%)	10.76	7.26	11.23	7.50
N (wt.%)	<0.3	0.94	<0.3	1.30
O[b] (wt.%)	71.87	30.85	77.80	24.65
pH	2.84	4.10	3.37	4.40
Density (g/cm^3)	1.0705	1.1550	1.0392	1.1766
High heating value (MJ/kg)	–	22.06	–	23.86
Na content (ppm)	46	38	19	36
K content (ppm)	19	116	13	41
Ca content (ppm)	82	60	57	23
Mg content (ppm)	8	8	8	1

[a] The total water yield during the reaction process is equal to the sum of the product of mass and water content at each condenser. The ratio of the collected water content of oil for each condenser is equal to the collected water yield at each condenser divided by the total water yield.

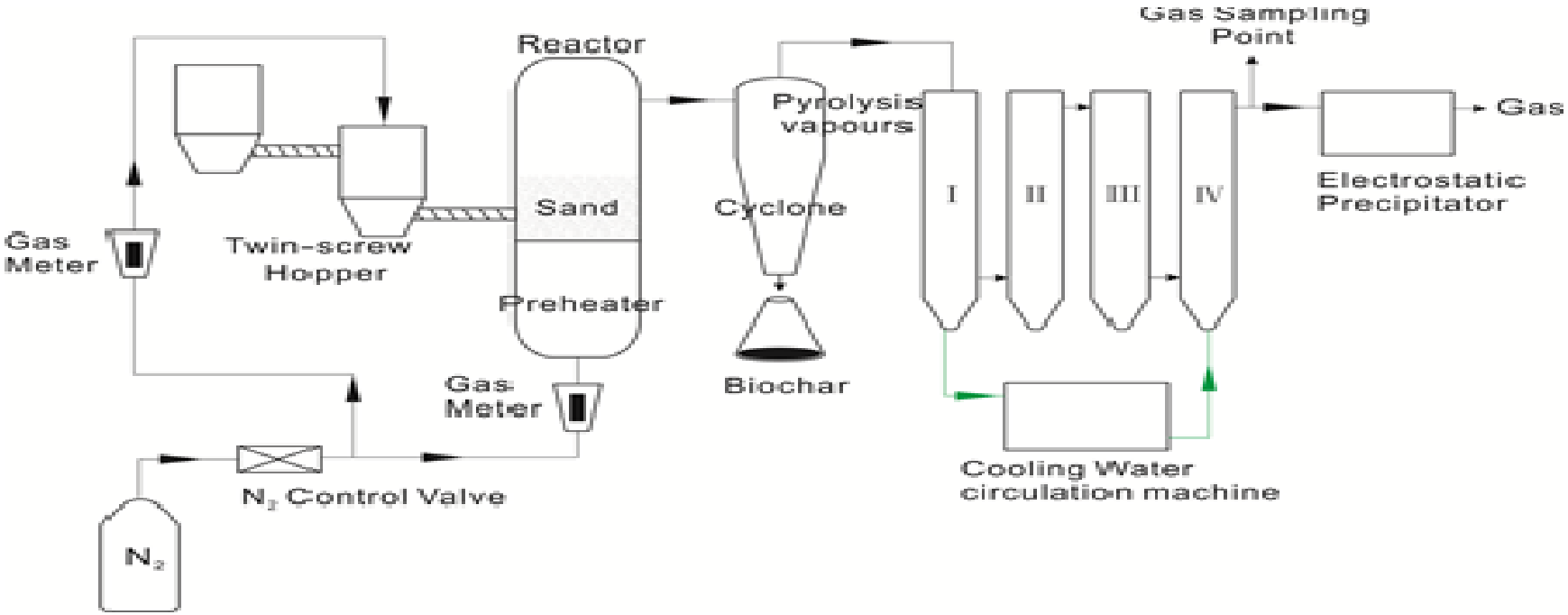
[b] By difference.

[c] C_1, C_2 were the bio-oil condensed in the condenser and EP when using the cyclone only to remove the solid particle, and F_1, F_2 were the bio-oil condensed in the condenser and EP when using the cyclone coupled with HVF.

Conclusion:

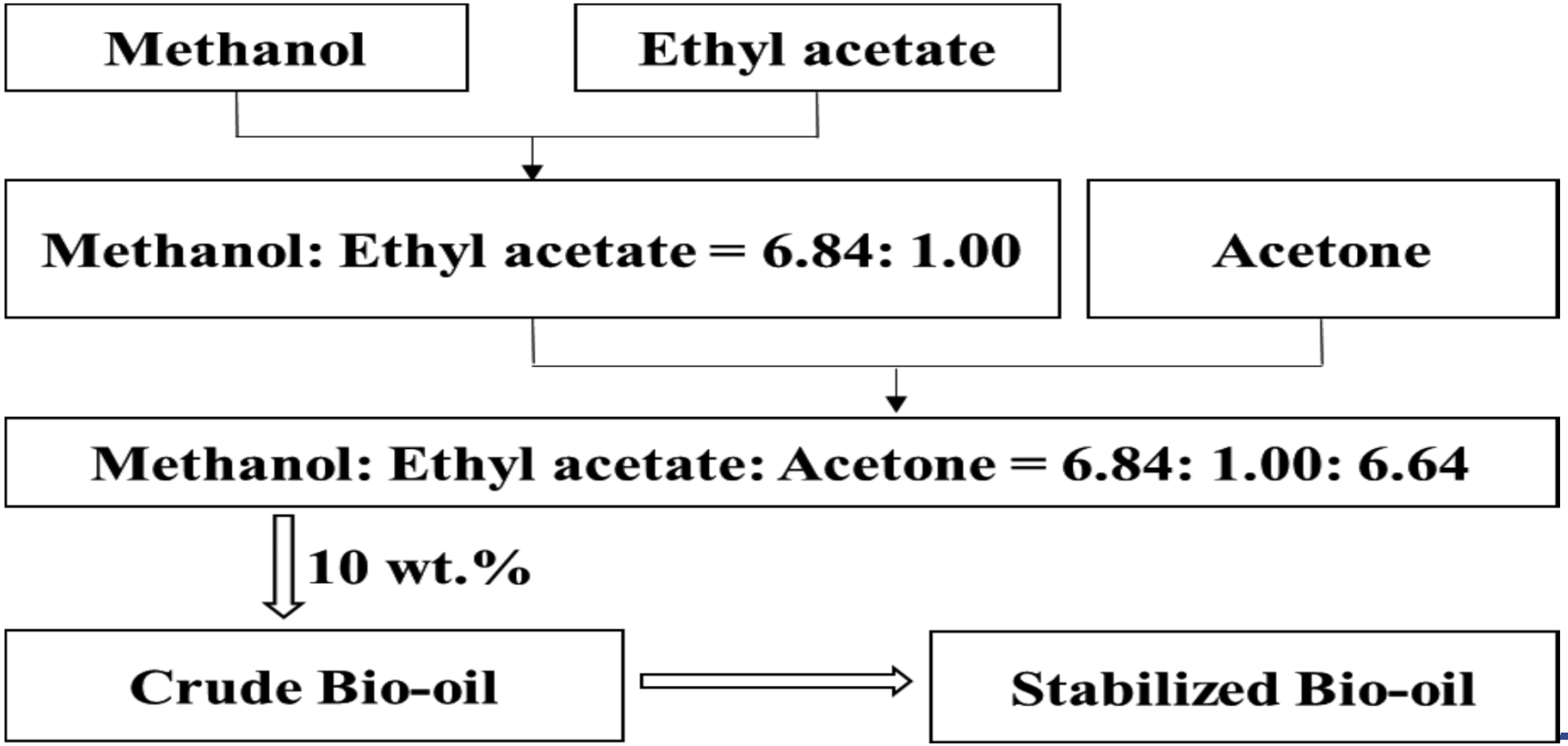
It was found that the total bio-oil yield decreased and that the bio-oil has a higher water content, higher pH value, and lower alkali metal content when a HVF is used in the system.

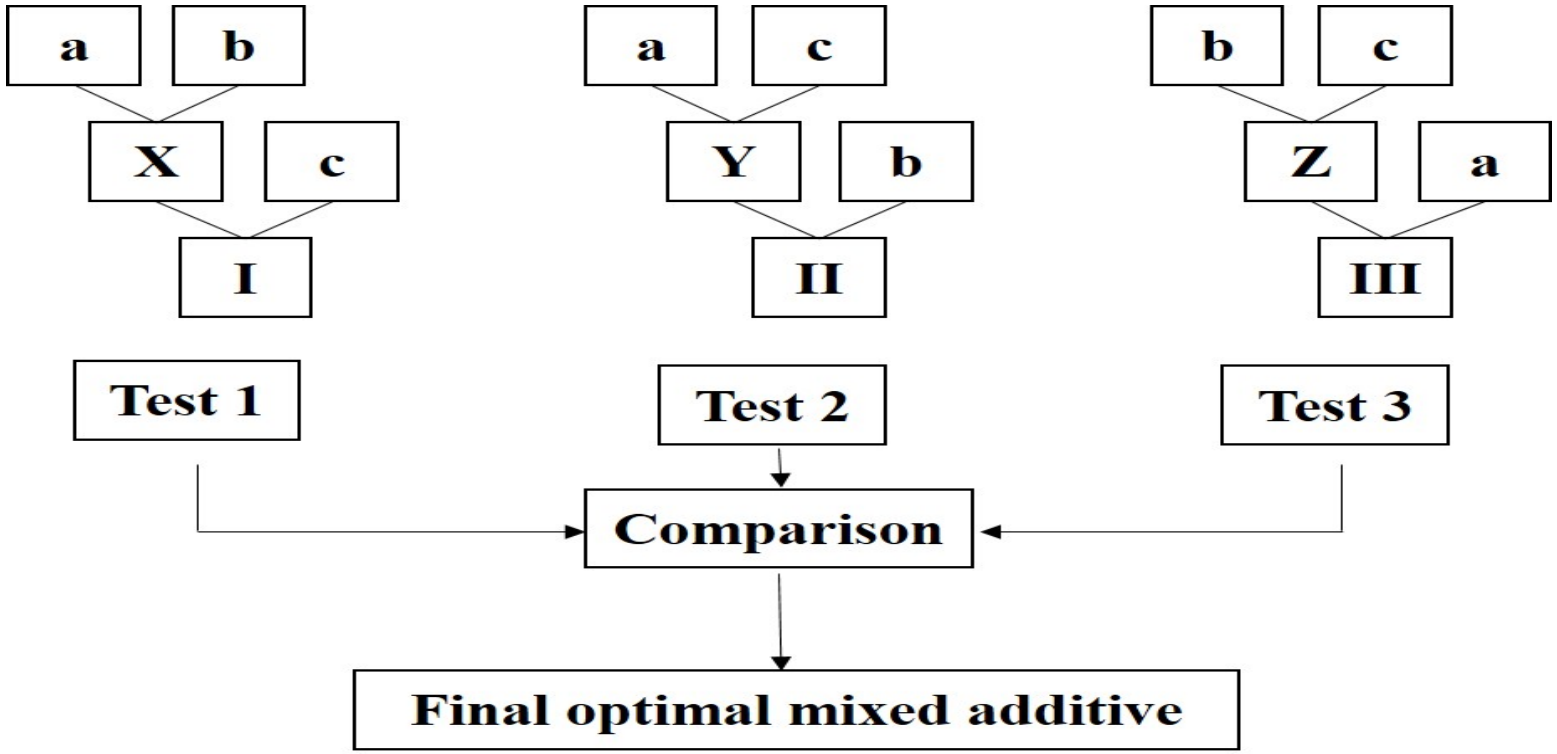
*Effect of Selective Condensation on the Characterization of Bio-oil from Pine Sawdust Fast Pyrolysis Using a Fluidized-Bed Reactor



The flow chart of the fluidized bed reactor fast pyrolysis system

*Optimization of a Mixed Additive and its Effect on Physicochemical Properties of Bio-Oil

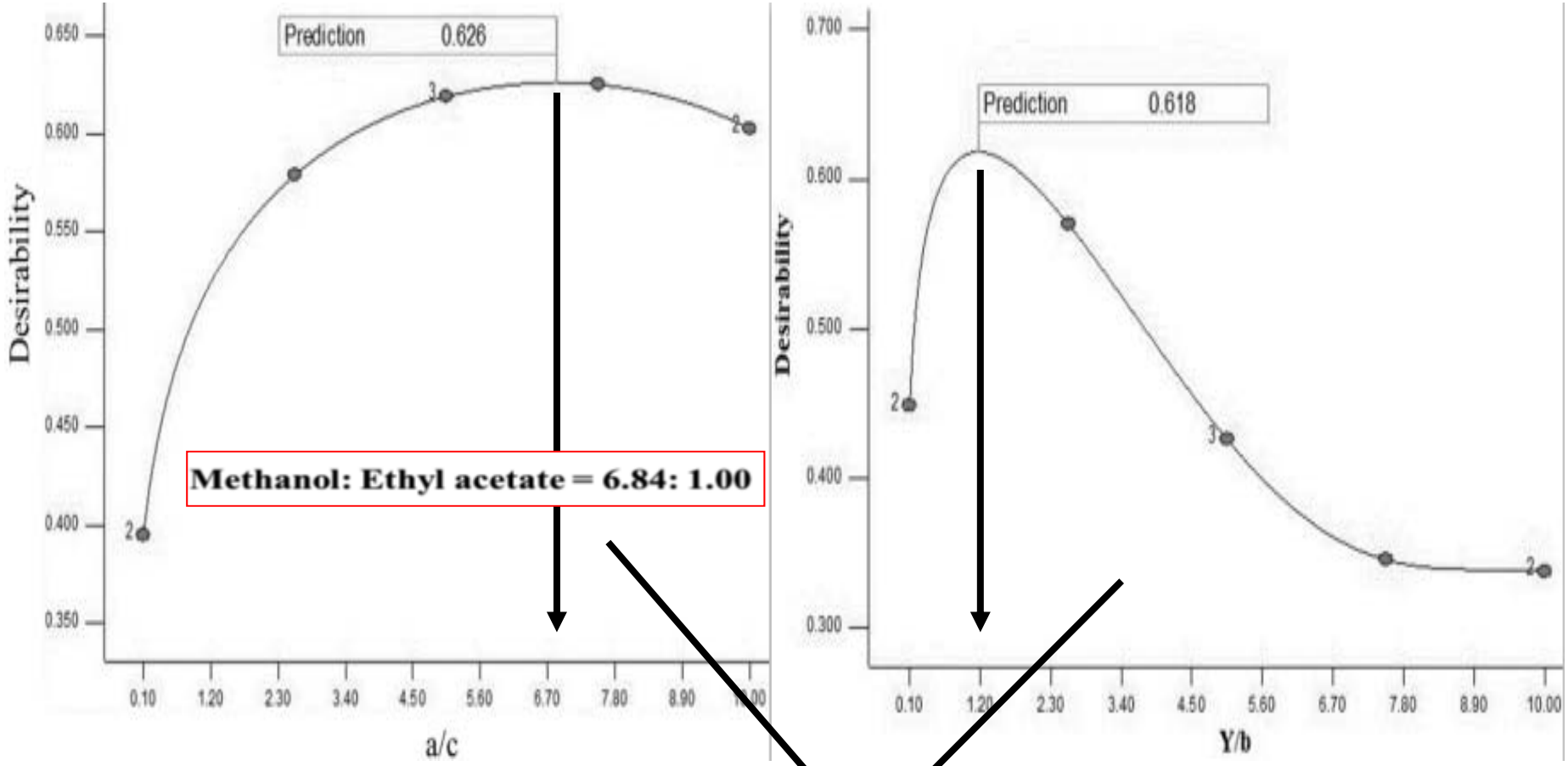




The diagram of the whole optimization experiment

a	methanol
b	acetone
c	ethyl acetate

Results of Test 2



Methanol: Ethyl acetate: Acetone = 6.84: 1.00: 6.64

Optimization curves of the proportion of (1) a to c and (2) Y to b

Project Title: Development of Equipment for Biomass Fast Pyrolysis for Bio-oil Production and its Demonstration in Thousand Ton Scale

Organizer: Shanghai JiaoTong University

Partners:1) Zhejiang University

2)Shandong University of Technology

3)Guangzhou Institute of Energy Conversion, Chinese Academy of Science

4)University of Science and Technology of China

5) University of Science and Technology of South China

6) Company

Coordinator of the project: Ronghou Liu

Period: January 2011-December 2013

Budget from MOST:

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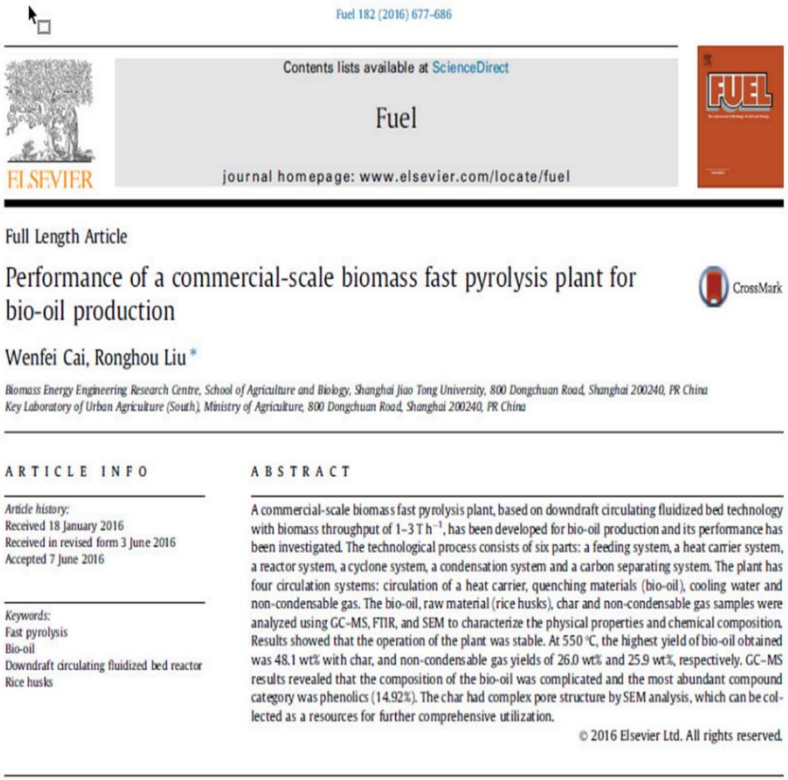
A demonstration plant of biomass fast pyrolysis with bio-oil yield:10000 t/a in Shaanxi has been jointly built by Shanxi Yingjiliang Company and Shanghai Jiao Tong University, China



Fuel 182 (2016) 677–686

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Fuel

journal homepage: www.elsevier.com/locate/fuel

Full Length Article

Performance of a commercial-scale biomass fast pyrolysis plant for bio-oil production

Wenfei Cai, Ronghou Liu *

Biomass Energy Engineering Research Centre, School of Agriculture and Biology, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, PR China
Key Laboratory of Urban Agriculture (South), Ministry of Agriculture, 800 Dongchuan Road, Shanghai 200240, PR China

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ABSTRACT

A commercial-scale biomass fast pyrolysis plant, based on downdraft circulating fluidized bed technology with biomass throughput of 1–3 T h^{-1}, has been developed for bio-oil production and its performance has been investigated. The technological process consists of six parts: a feeding system, a heat carrier system, a reactor system, a cyclone system, a condensation system and a carbon separating system. The plant has four circulation systems: circulation of a heat carrier, quenching materials (bio-oil), cooling water and non-condensable gas. The bio-oil, raw material (rice husks), char and non-condensable gas samples were analyzed using GC–MS, FTIR, and SEM to characterize the physical properties and chemical composition. Results showed that the operation of the plant was stable. At 550 °C, the highest yield of bio-oil obtained was 48.1 wt% with char, and non-condensable gas yields of 26.0 wt% and 25.9 wt%, respectively. GC–MS results revealed that the composition of the bio-oil was complicated and the most abundant compound category was phenolics (14.92%). The char had complex pore structure by SEM analysis, which can be collected as a resources for further comprehensive utilization.

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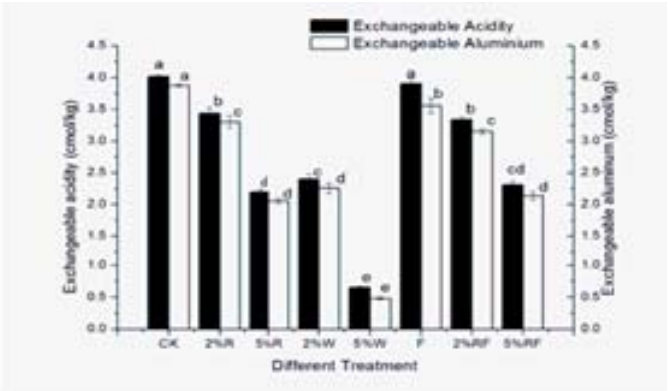
3.Biochar Application for Soil Amendment

-863 Project by MOST

1)Developed a biochar application machine:

Scale：4753.8-34185.2 kg/h

2) The effect of biochar on soil and plant growth



Wood sawdust biochar could reduce the exchangeable acidity and aluminum by 84% and 88%, respectively at the 5% biochar amendment level.

4.Bioethanol

Available online at www.sciencedirect.com
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Bioresource Technology 99 (2008) 847–854
BIORESOURCE TECHNOLOGY

Impacts of main factors on bioethanol fermentation from stalk juice of sweet sorghum by immobilized *Saccharomyces cerevisiae* (CICC 1308)

Ronghou Liu *, Fei Shen

Biomass Energy Engineering Research Centre, School of Agriculture and Biology, Shanghai JiaoTong University, 2678 Qi Xin Road, Shanghai 201101, PR China

Received 17 October 2006; received in revised form 17 January 2007; accepted 17 January 2007
Available online 13 March 2007

Abstract

In order to attain a higher ethanol yield and faster ethanol fermentation rate, orthogonal experiments of ethanol fermentation with immobilized yeast from stalk juice of sweet sorghum were carried out in the shaking flasks to investigate the effect of main factors, namely, fermentation temperature, agitation rate, particles stuffing rate and pH on ethanol yield and CO_2 weight loss rate. The range analysis and analysis of variance (ANOVA) were applied for the results of orthogonal experiments. Results showed that the optimal condition for bioethanol fermentation should be $A_4B_3C_3D_4$, namely, fermentation temperature, agitation rate, particles stuffing rate and pH were 37 °C, 200 rpm, 25% and 5.0, respectively. The verification experiments were carried out in shaking flasks and 5 L bioreactor at the corresponding parameters. The results of verification experiments in the shaking flasks showed that ethanol yield and CO_2 weight loss

This paper has been Top 20 Articles, in the Domain of Article 17360181, Since its Publication (2008)

1. Introduction

Ethanol production as an alternative fuel energy resource has been a subject of great interest since the oil crisis of the 1970s (Tao et al., 2005). Therefore, a strong need exists for efficient ethanol production with low cost in raw material and production process. The varied raw materials used in the production of ethanol via fermentation are conveniently classified into three main types of raw materials: sugars, starches, and cellulose materials. Sugars (from sugarcane, sugar beets, sweet sorghum, molasses, and fruits) can be converted into ethanol directly. Starches (from corn, cassava, potatoes, and root crops) must firstly be hydrolyzed to fermentable sugars by the action of enzymes from malt or molds. Cellulose (from wood, agricultural residues, waste sulfite liquor from pulp, and paper mills) must likewise be converted into sugars, generally by the action of mineral acids. Once simple sugars are formed, enzymes from microorganisms can readily ferment them to ethanol (Lin and Tanaka, 2006). As for materials, one of the prime sources being investigated for ethanol is sweet sorghum. Sweet sorghum {*Sorghum biocolor* (L.) Moench} is a high biomass- and sugar-yielding crops (Bryan, 1990), meantime, the stalk of sweet sorghum contains quite a few quantities of soluble (glucose and sucrose) and insoluble carbohydrates (cellulose and hemicellulose) (Jasberg et al., 1983). Therefore, of many crops currently being investigated for energy and industry, sweet sorghum is one of the most promising, particularly for ethanol production (Gnansounou et al., 2005).

The advantages of immobilized cells over free cell sys-

* Corresponding author. Tel.: +86 21 64783844; fax: +86 21 64193285.

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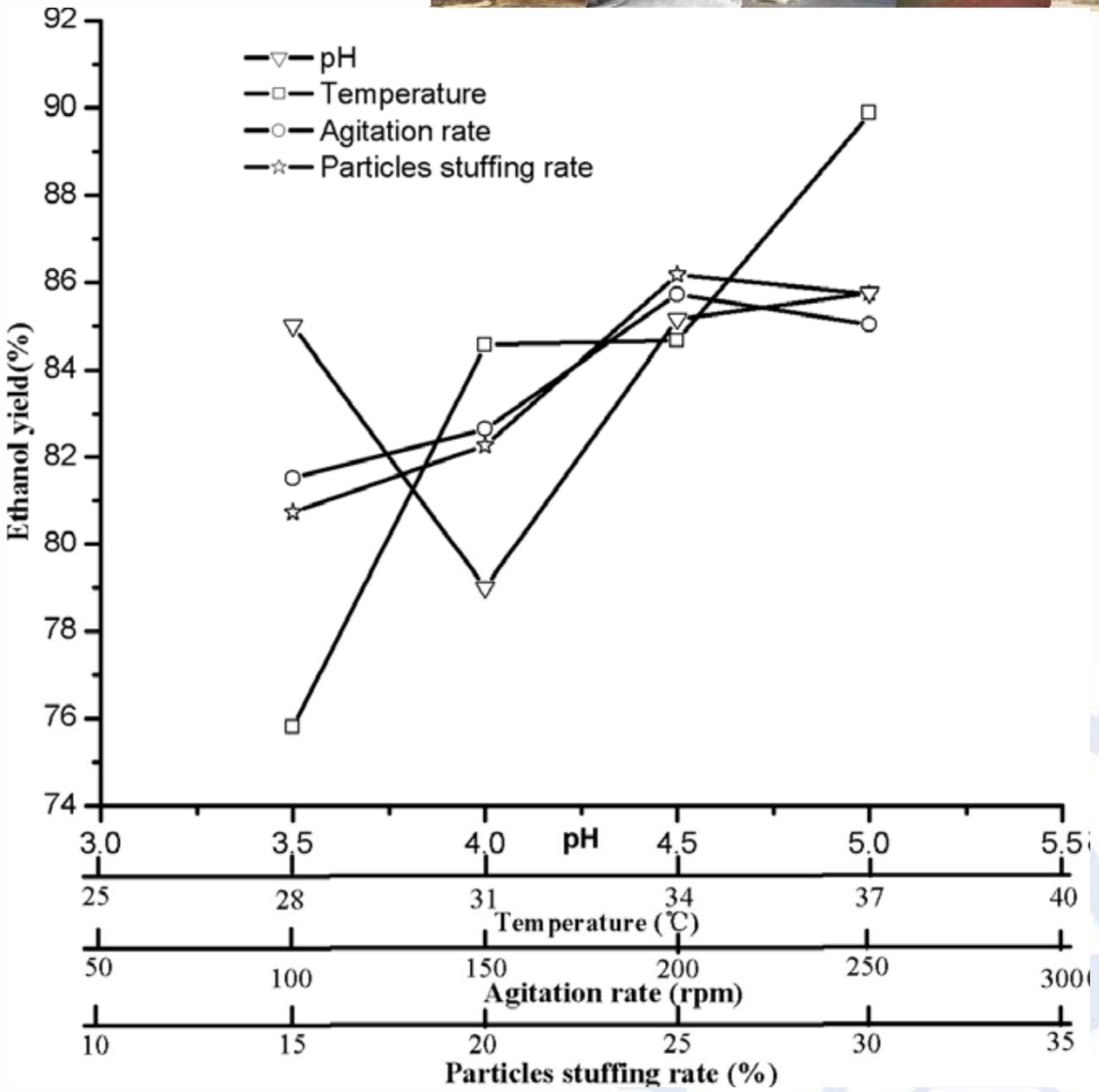
Optimal condition for bioethanol fermentation:

Fermentation temperature:37 ° C , agitation rate 200 rpm,
particles stuffing rate:25%,
pH 5.0.
Ethanol yield:98.07%,
Fermentation time 11 h.



Biogas production from undiluted chicken manure and maize silage: A study of ammonia inhibition in high solids anaerobic digestion

Chen Sun[1,2], *Weixing Cao*[1], *Charles J. Banks*[2], *Sonia Heaven*[2], *Ronghou Liu**[1,2]

1. Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, People's Republic of China.

2. University of Southampton, Southampton SO17 1BJ, UK.

Corresponding author, Ronghou Liu,

Telephone (Fax): 0086 21 34205744.

Email address: liurhou@sjtu.edu.cn

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Objectives:

- To evaluate the multi-inhibited AD system using CM and MS as the feedstock without any water addition;
- To determine the thresholds for ammonia inhibition/toxicity;

Conclusions:

- Methanogenesis was totally inhibited at TAN >9 g N L^{-1}. 14C isotope labelling showed the predominant methanogenic pathway at high TAN was hydrogenotrophic.

Bioresource Technology 218 (2016) 1215–1223

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Bioresource Technology

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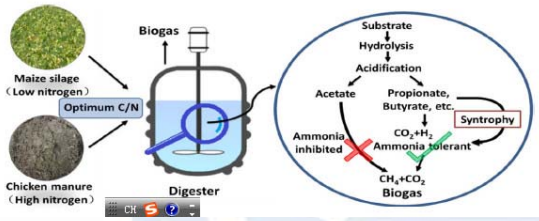
Chen Sun [a,b,c], Weixing Cao [a,c], Charles J. Banks [b], Sonia Heaven [b], Ronghou Liu [a,b,c,*]

[a] Biomass Energy Engineering Research Centre, School of Agriculture and Biology, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, People's Republic of China
[b] Faculty of Engineering and the Environment, University of Southampton, Southampton SO17 1BJ, UK
[c] Key Laboratory of Urban Agriculture (South), Ministry of Agriculture, 800 Dongchuan Road, Shanghai 200240, People's Republic of China

HIGHLIGHTS

- Stable co-digestion of up to 20% chicken manure on VS basis with maize silage.
- Threshold and total inhibition of biogas production occurred at 7 and 9 g N L^{-1}.
- Dominant hydrogenotrophic methanogenesis reverts to acetoclastic on lower N input.
- Loss of methanogenesis led to total VFA > 60 g L^{-1} before buffering failed.
- Sub-optimal solids breakdown as a result of multi-inhibition.

GRAPHICAL ABSTRACT



energy&fuels

Article

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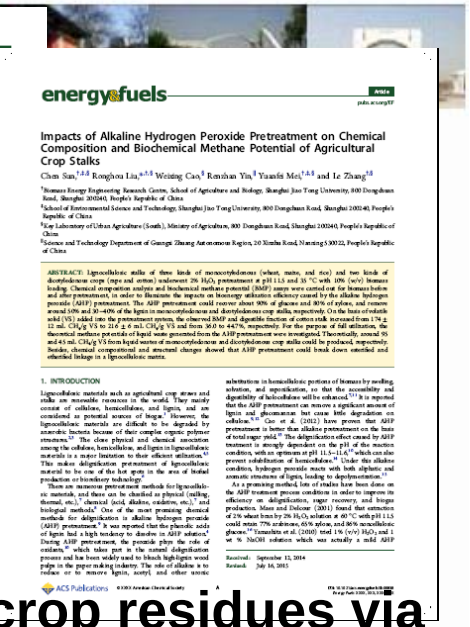
Impacts of Alkaline Hydrogen Peroxide Pretreatment on Chemical Composition and Biochemical Methane Potential of Agricultural Crop Stalks

Chen Sun,[†,‡,§] Ronghou Liu,[*,†,§] Weixing Cao,[§] Renzhan Yin,[∥] Yuanfei Mei,[†,‡,§] and Le Zhang[†,§]



Objective:

to increase bio-digestibility and methane yield from crop residues via pretreatment

Results and conclusions:

The AHP pretreatment could:

- break down esterified(酯化） and etherified（醚化） linkage in lignocellulose;
- recover 90% of glucose and 80% of xylose（木糖）;
- remove 30%-50% of lignin;
- increased methane yield and bio-digestibility for certain biomass.

It is necessary to utilize the liquid waste from the pretreatment.

Selected Publications(SCI)

1) Wenfei Cai, Ronghou Liu*. Performance of a commercial-scale biomass fast pyrolysis plant for bio-oil production[J]. Fuel 182 (2016) 677–686.

2) Renzhan Yin, Le Zhang , Ronghou Liu*, Yuanfei Mei , Wenjuan Yu. Optimization of composite additives for improving stability of bio-oils, Fuel 170 (2016) 1–8.

3) Tianju Chen, Ceng Wu, Ronghou Liu*. Steam reforming of bio-oil from rice husks fast pyrolysis for hydrogen production[J]. Bioresource Technology, 2011, 102, 9236-9240.

4) Chen Sun, Weixing Cao, Charles J. Banks, Sonia Heaven, Ronghou Liu*.Biogas production from undiluted chicken manure and maize silage: a study of ammonia inhibition in high solids anaerobic digestion[J]. Bioresource Technology, Volume 218, October 2016, Pages 1215-1223.

5) Kun Li, Ronghou Liu*, Chen Sun. Comparison of anaerobic digestion characteristics and kinetics of four livestock manures with different substrate concentrations[J].Bioresource Technology, 198 (2015) 133–140.

6） **Renzhan Yin, Ronghou Liu*, Yuanfei Mei, et al.Characterization of bio-oil and bio-char obtained from sweet sorghum bagasse fast pyrolysis with fractional condensers[J].Fuel , Volume 112, October 2013, Pages 96–104.**

7） Le Zhang, Ronghou Liu*, Renzhan Yin, Yuanfei Mei.Upgrading of bio-oil from biomass fast pyrolysis in China: A review[J].Renewable and Sustainable Energy Reviews 24 (2013) 66–72.

8） **Tianju Chen, Ceng Wu, Ronghou Liu*, et al. Effect of hot vapor filtration on the characterization of bio-oil from rice husks with fast pyrolysis in a fluidized bed reactor[J]. Bioresource Technology, 2011, 102, 6178-6185.**

9） **Weixing Cao, Chen Sun, Ronghou Liu*, Renzhan Yin, Xiaowu Wu.Comparison of the effects of five pretreatment methods on enhancing the enzymatic digestibility and ethanol production from sweet sorghum bagasse[J].Bioresource Technology,Volume 111, May 2012, Pages 215–221.**

10) **Renzhan Yin, Ronghou Liu*, Jinkai Wu, Xiaowu Wu, Chen Sun, Ceng Wu. Influence of particle size on performance of a pilot-scale fixed-bed gasification system[J]. *Bioresource* Technology, 119 (2012) 15–21.**

6.Conclusion

Therefore, adequate conversion technology should be chosen according to concrete conditions in order to promote commercialization of biomass energy.

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Thank you！