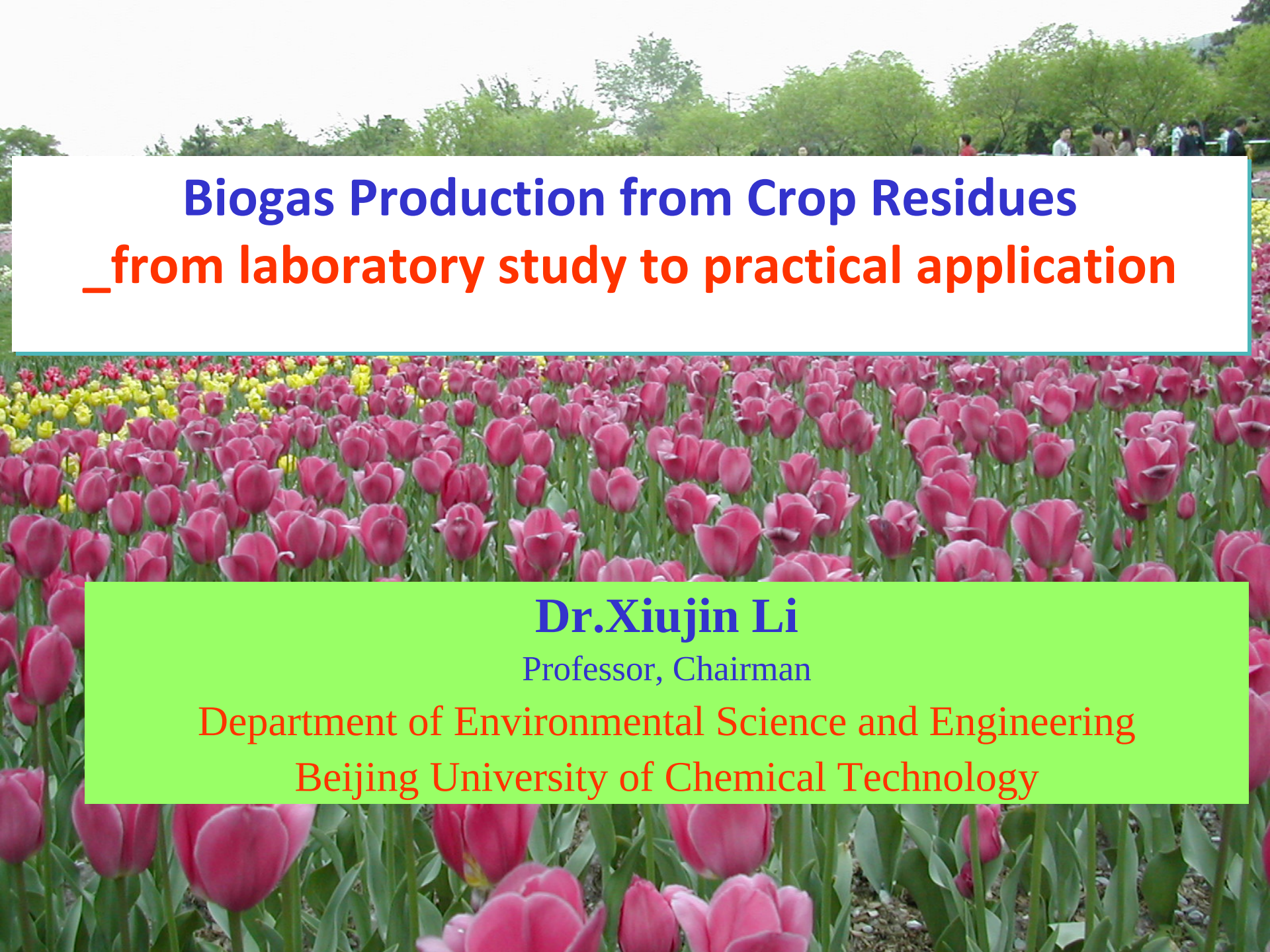


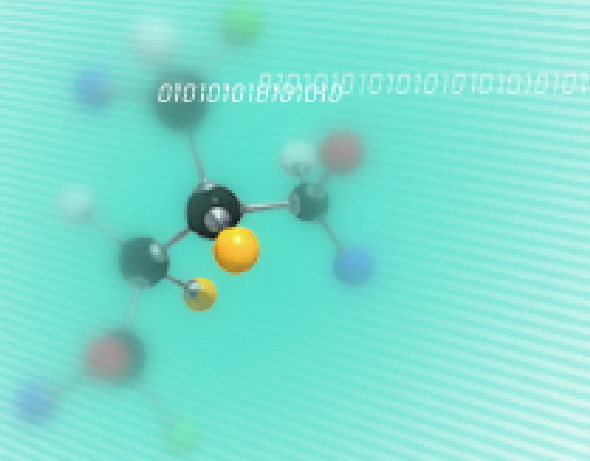
Biogas Production from Crop Residues _from laboratory study to practical application

Dr.Xiujin Li

Professor, Chairman

Department of Environmental Science and Engineering

Beijing University of Chemical Technology



Contents

1. Problems with crop residues and solutions
2. Key technologies to be developed
3. Demonstration and application projects
4. Conclusions

1. Problems with crop residues and solutions

1.1 Resource:

- China is one of the largest agricultural countries in the world with 0.9 billion farmers
- Crop residues -0.6 billion tons/a, corn stover, rice straw, and wheat straw are three major ones.
- About 50% used, leaving the rest (50%) unused.

1.2 Problems:

Environmental pollutions

Open-field burning-air pollution, fire disaster, traffic and aircraft safety.

Lack of feedstock for biogas production

- China has set the goal of 15% renewable energy in total energy consumption by 2020, biogas would be one of major contributors for reaching this goal;
- There are 22 million household small digesters exist, 20 million will be built by 2010 according to state plan;
- However, currently, animal manures are main feedstocks for biogas production, which are not

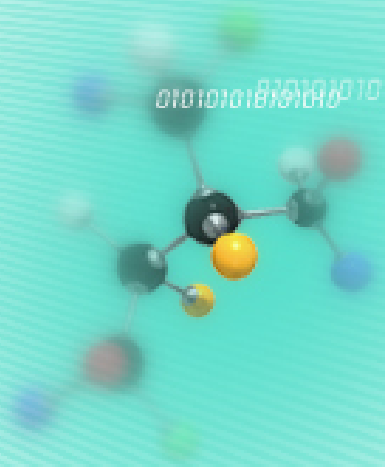
1.3 Utilization methods

- There are a number of utilization methods such as animal feed, direct combustion, gasification, pelletization etc.
- Anaerobic digestion is one of the effective technologies.
- However, most feedstocks used are readily biodegradable materials such as manure, food wastes , sludge etc.., very few attempts have been made to use crop residues for biogas production.

1.4 Reasons for not being used

- High percentage of lignocelluloses,which is not readily biodegradable.
- Low digestion rate and biogas yield .
- Specific material properties such as low density, large volume, and non mobility.

____Conventional AD technologies are not suitable to crop residues biogasification.



2. Key Technologies to be Developed

Anaerobic digestion technology is able to conversion from crop into bioenergy and fertilizer, if following key technologies are successfully developed.

(1) Pretreatment

_improve biodegradability and increase yield

(2)Specifically-designed bioreactor

_provide suitable place for bacteria growth

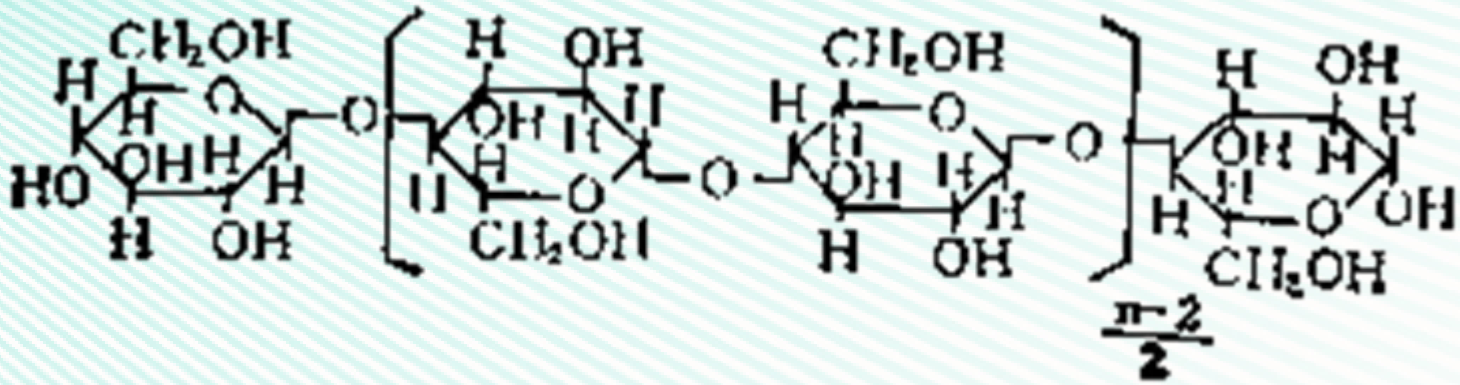
(3)Optimized operational parameters

-provide optimal living conditions for bacteria

(1) Pretreatment

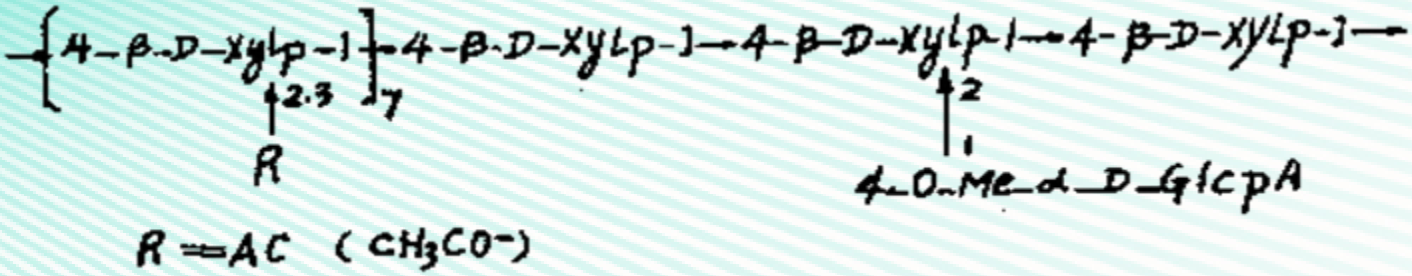
Cellulose

- A linear polymeric compound which is built up by coupling β、D-glucose using 1,4-glycosidic bonds.

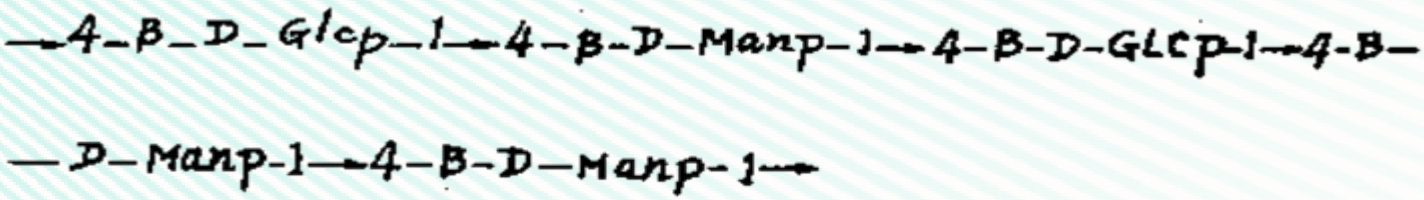


Hemicellulose

- a group of polysaccharides



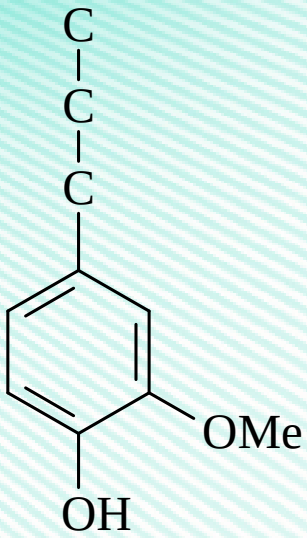
Poly-O-acetyl-4-O-methyl-glucuronic acid-xylose



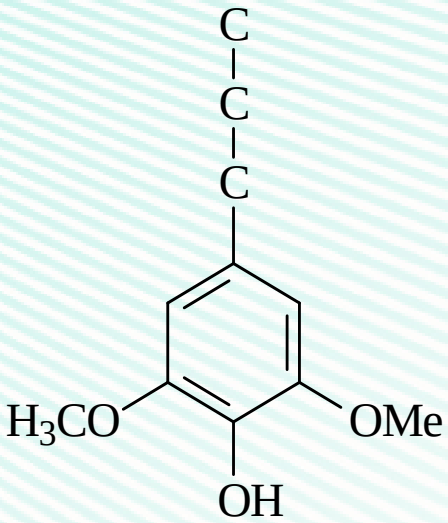
Poly-glucose-mannose

Lignin

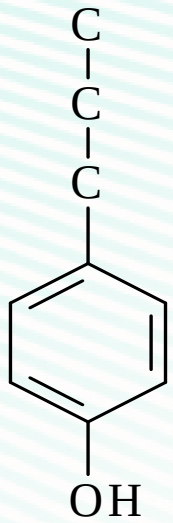
- It is built up by oxidative coupling of three major C_6–C_3 units, which forms a randomized structure in a tri-dimensional network inside the cell walls.



Guaiacyl alcohol (G)



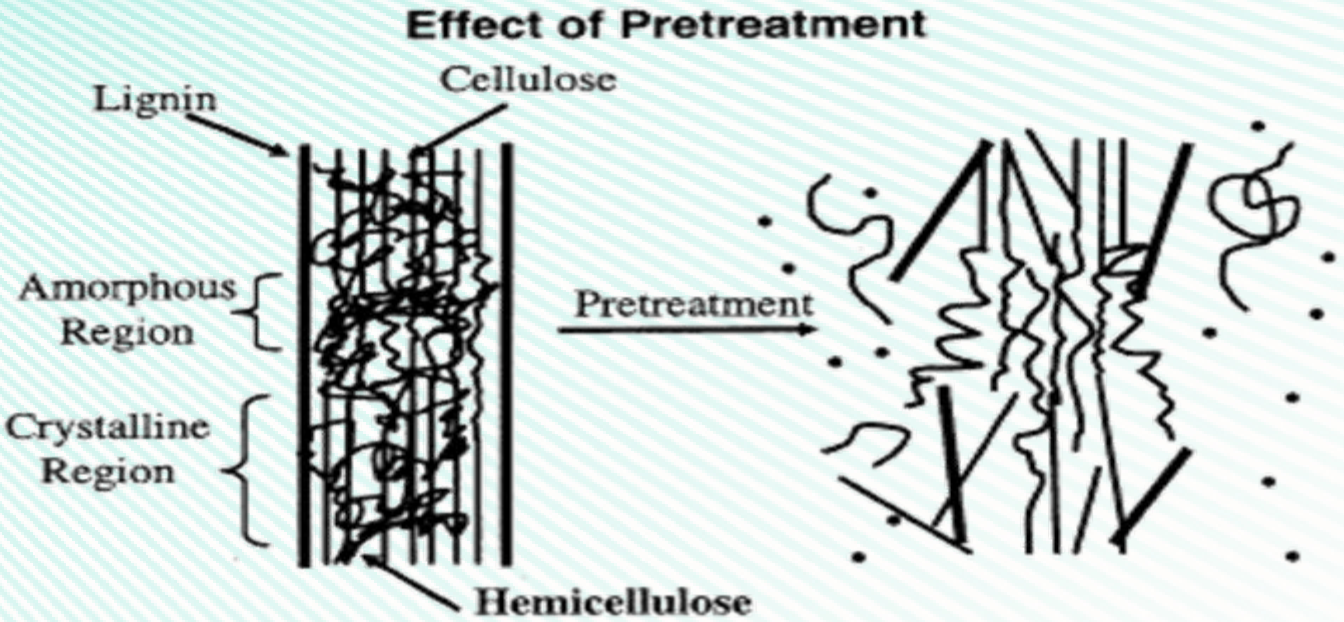
Syringyl alcohol(S)



p-Coumaryl alcohol(H)

(1) Pretreatment-purposes

- Break-down the linkages between lignin, cellulose, and hemicellulose _make more compositions more accessible;
- Decompose lignin, cellulose, and hemicellulose - biodegradable;
- Destroy micro-structure of cell wall –enlarge contact surface



(1) Pretreatment-methods

- **Physical methods**
  - Mechanical treatment, Steam-explosion , Microwave treatment
    - Not very effective, sometimes high energy, expensive
- **Biological methods**
  - Using some fungi and enzymes
    - High requirements, high cost, hard to be applied in practice
- **Chemical methods**
  - Alkali treatment, Acid treatment, Oxidation
    - Easy, Cheap, good effect, but may cause pollution

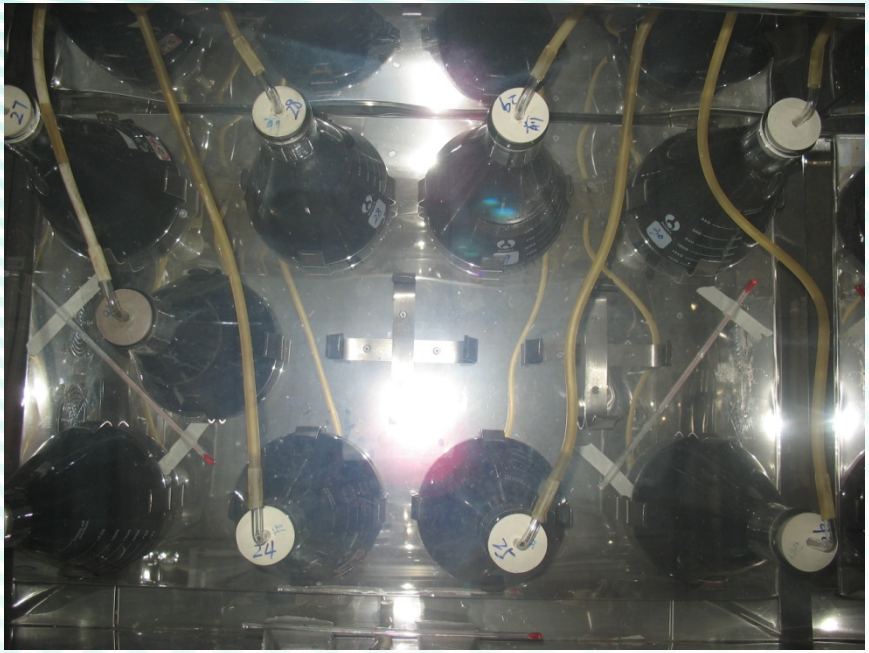
Solid-state pretreatment with Sodium Hydroxide(NaOH) was chosen and used in our study:

easy, cheap, fast, no second-time pollution

Solid-state chemical pretreatment of corn stalk

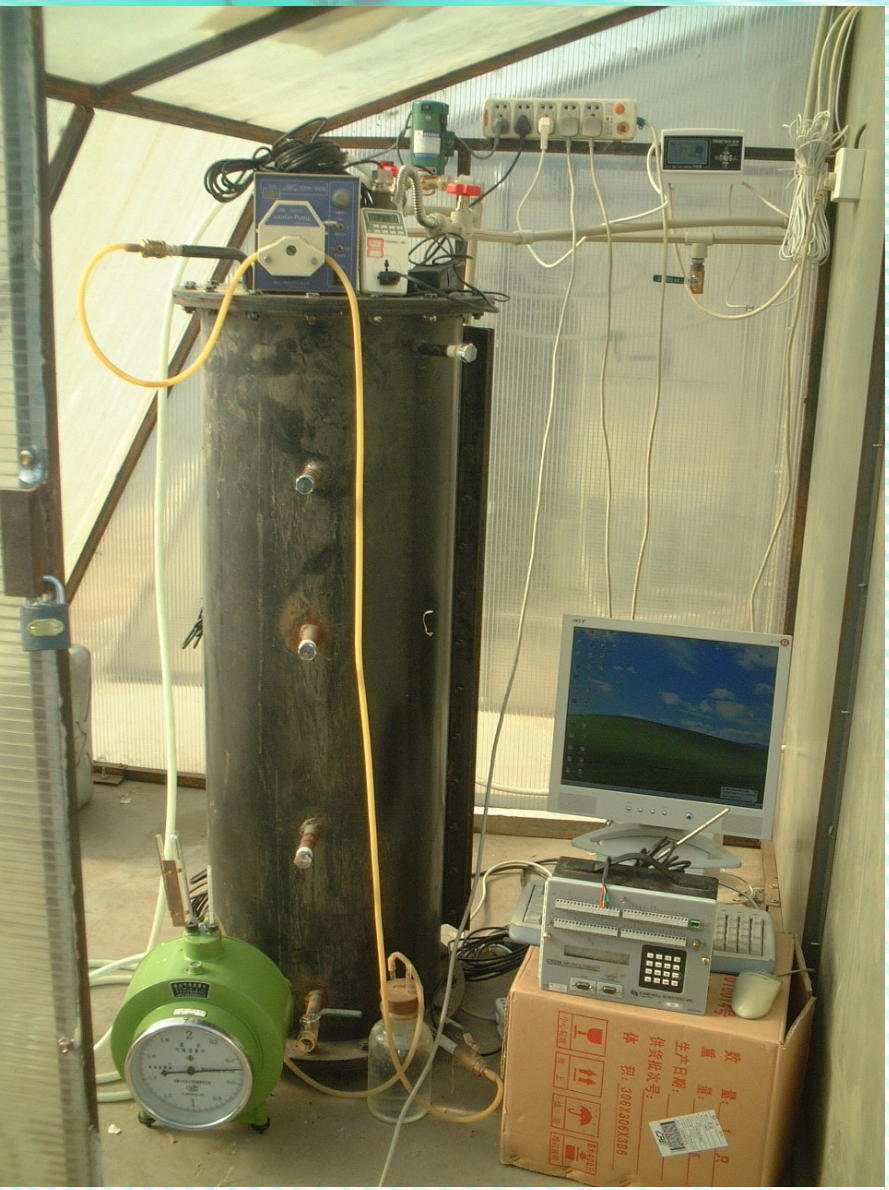
(2)Specifically-designed bioreactor

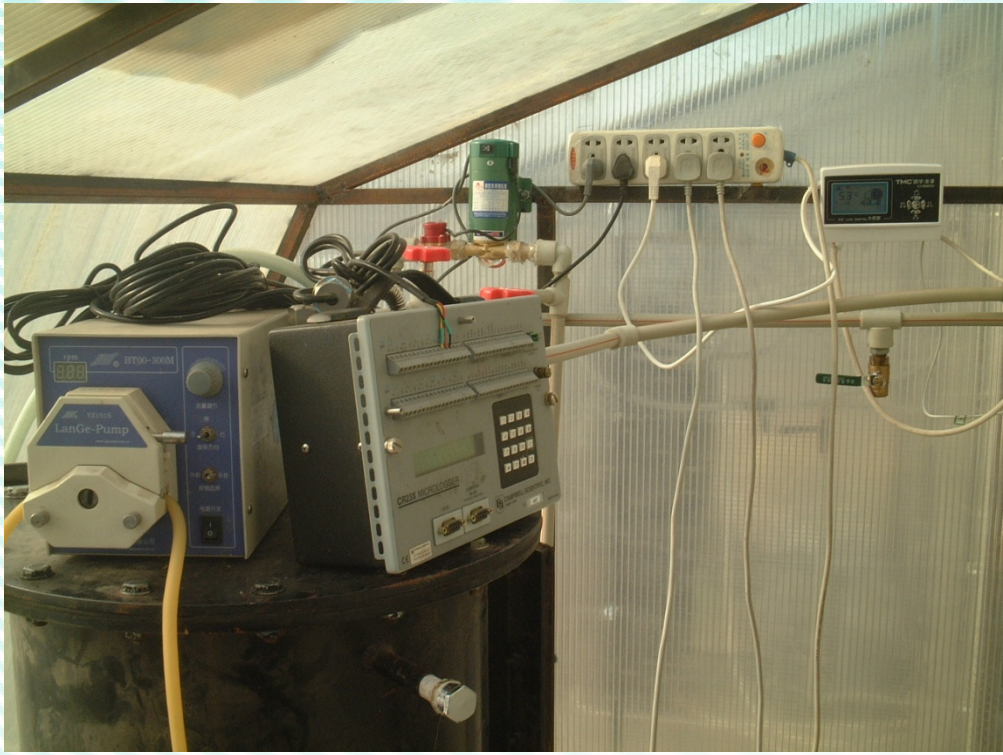
- **Experimental setup**



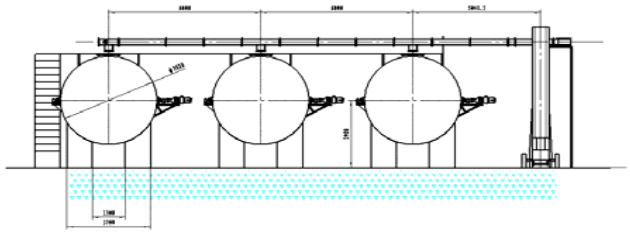
(2)Specifically-designed bioreactor

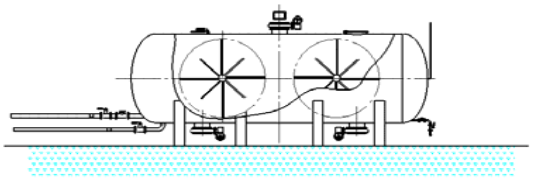
(2)Specifically-designed bioreactor

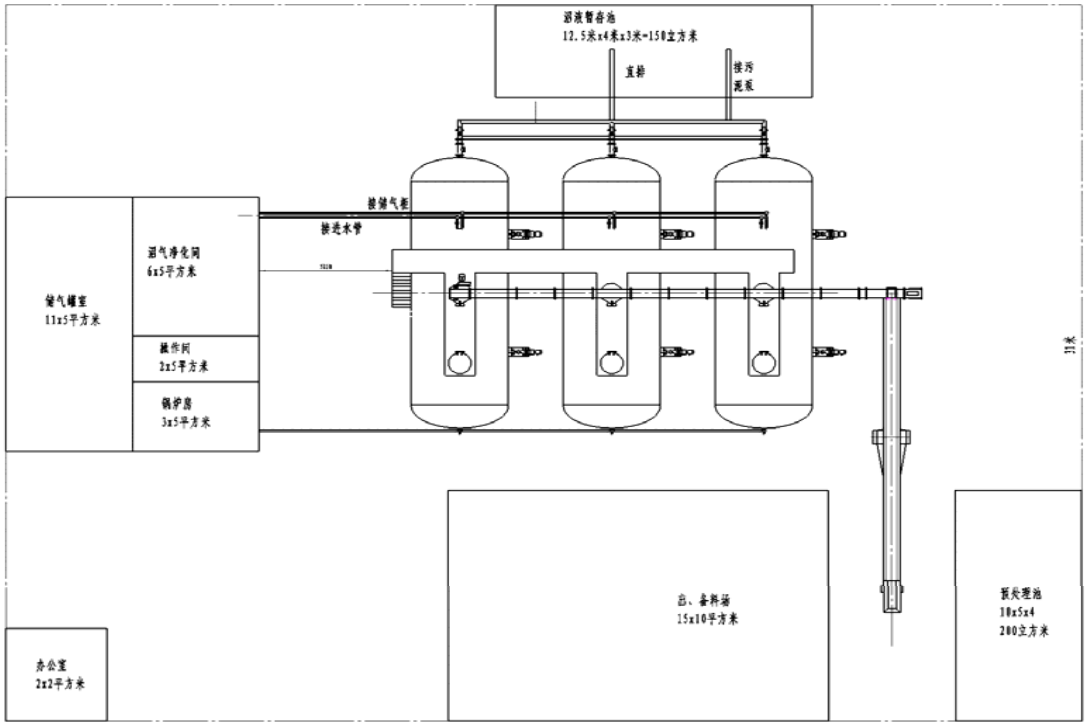




(2)Specifically-designed Anaerobic Digester(50m3)







说明

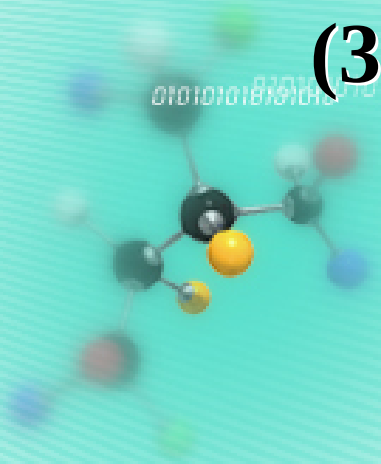
罩剖板输送机支架结构尺寸由生产厂家确定。
主要建筑完成及设备安装后，焊接安装扶梯与走道，具体结构安装时确定，注意应便利进料口处法兰盖的开启。
蒸汽管道、净水管及储气管道径DN50。
进出污水管道通径DN150。

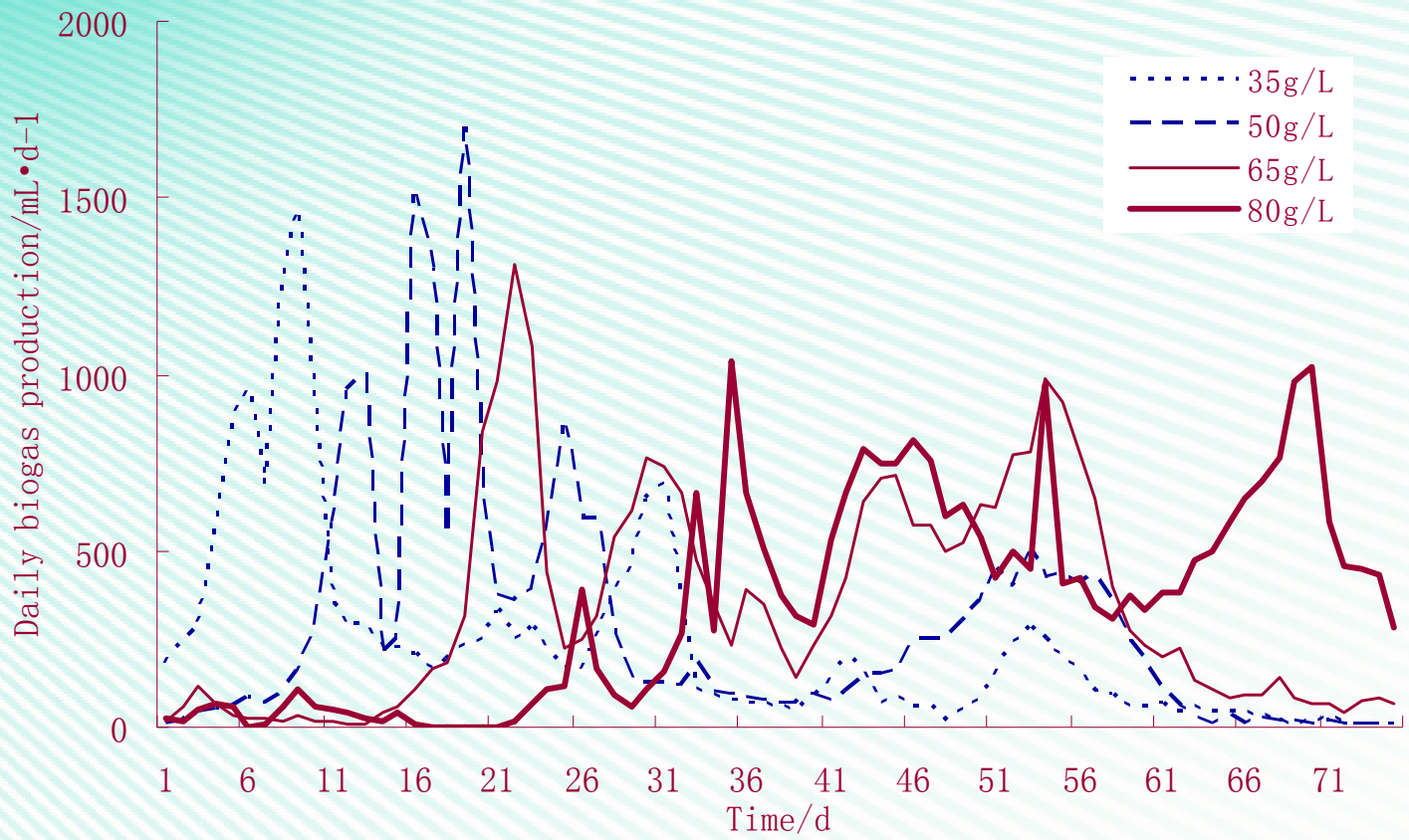
北京化工大学
工艺布置图
GYP500.1

(2) Specifically-designed Anaerobic Digester(50m3)

(2)Specifically-designed Anaerobic Digester(250m3)

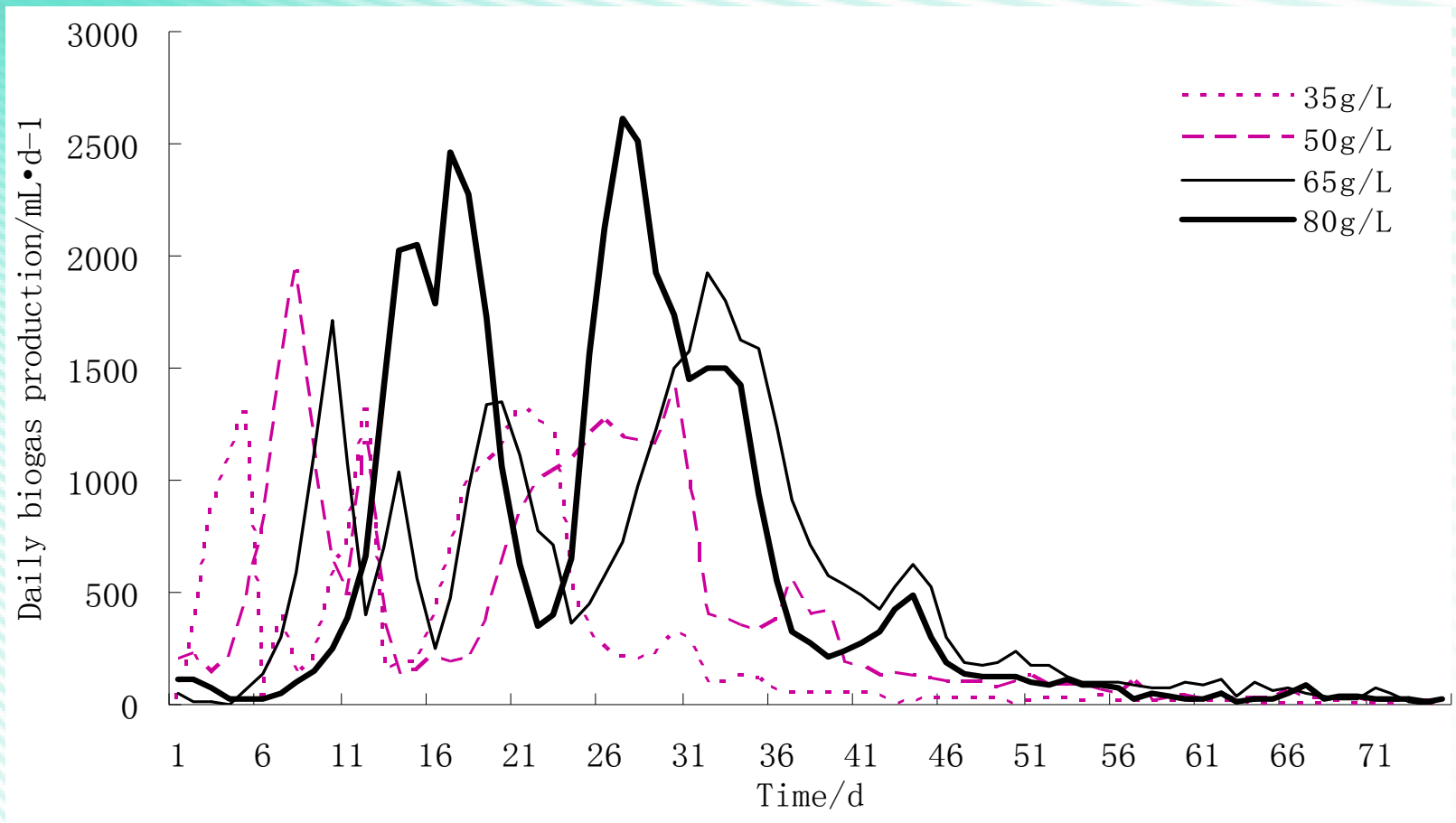
(3)Optimized operational parameters





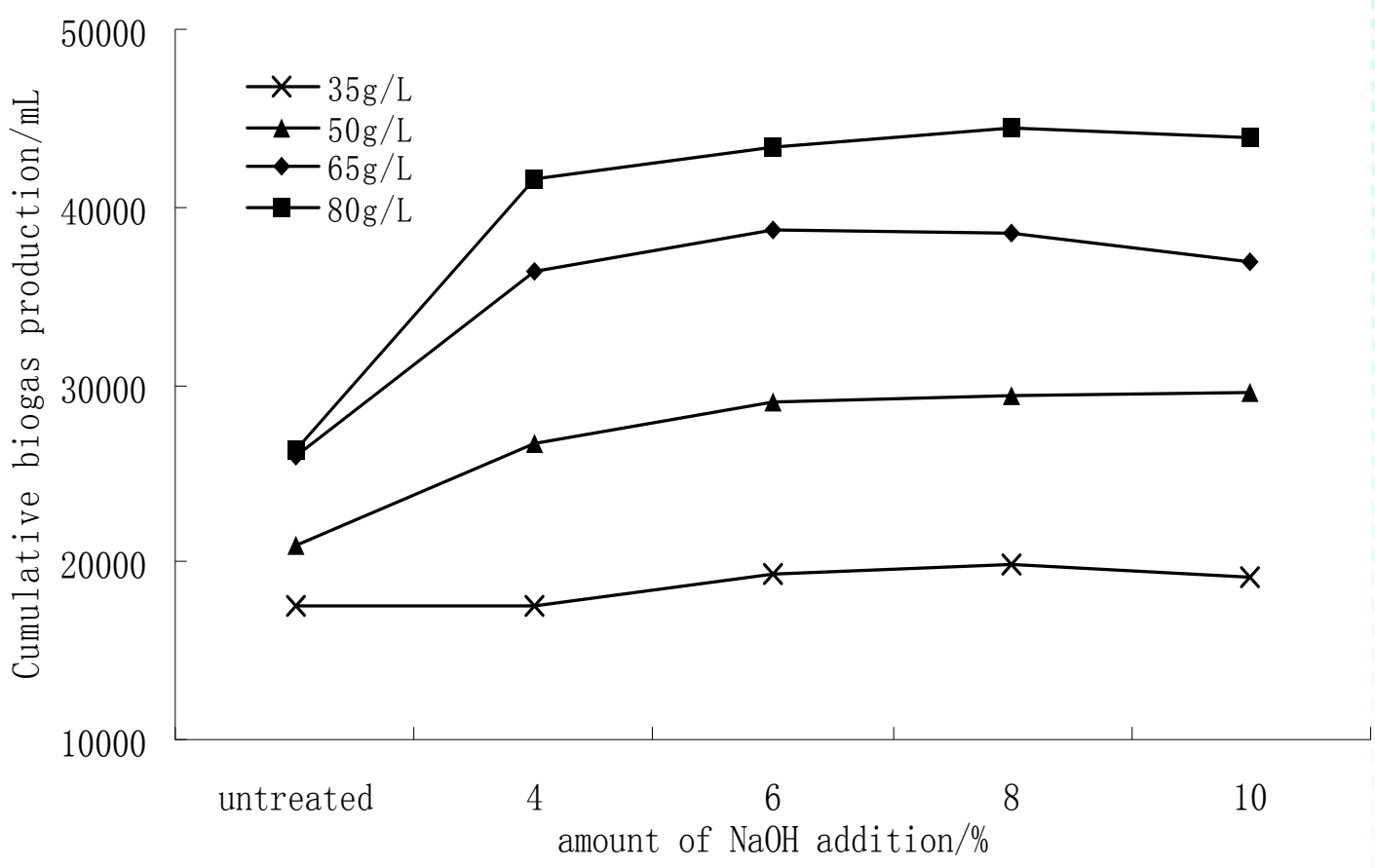
(3)Optimized operational parameters

Daily biogas production —chemical li-treated corn stalk



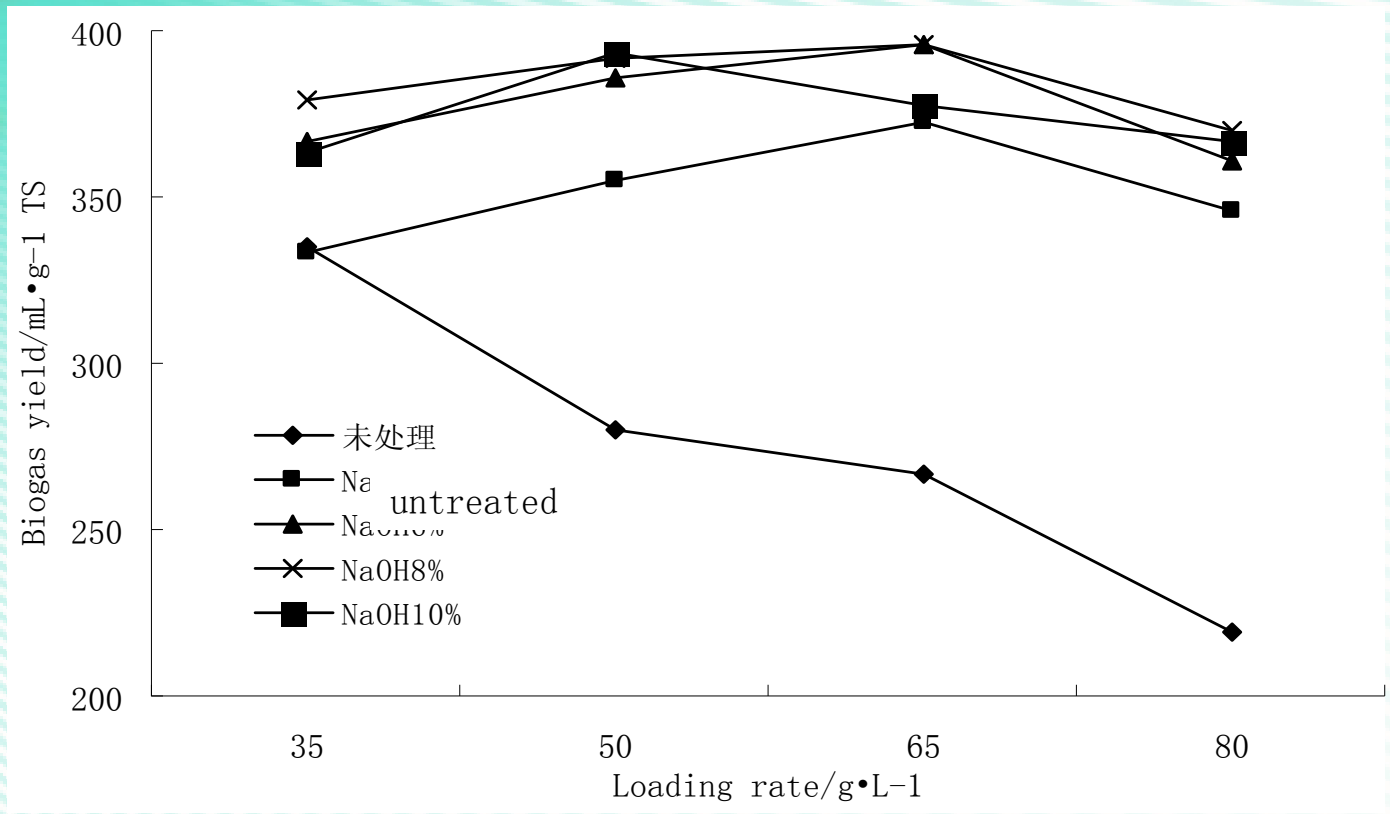
(3)Optimized operational parameters

Comparison on cumulative biogas production of untreated and NaOH



(3)Optimized operational parameters

2. 3 Biogas yield per gram TS loaded



Recommendation:

Chemical pretreatment + digested at optimal loading rate ⟶ more than 50% increase of biogas yield

(3)Optimized operational parameters

Methane content

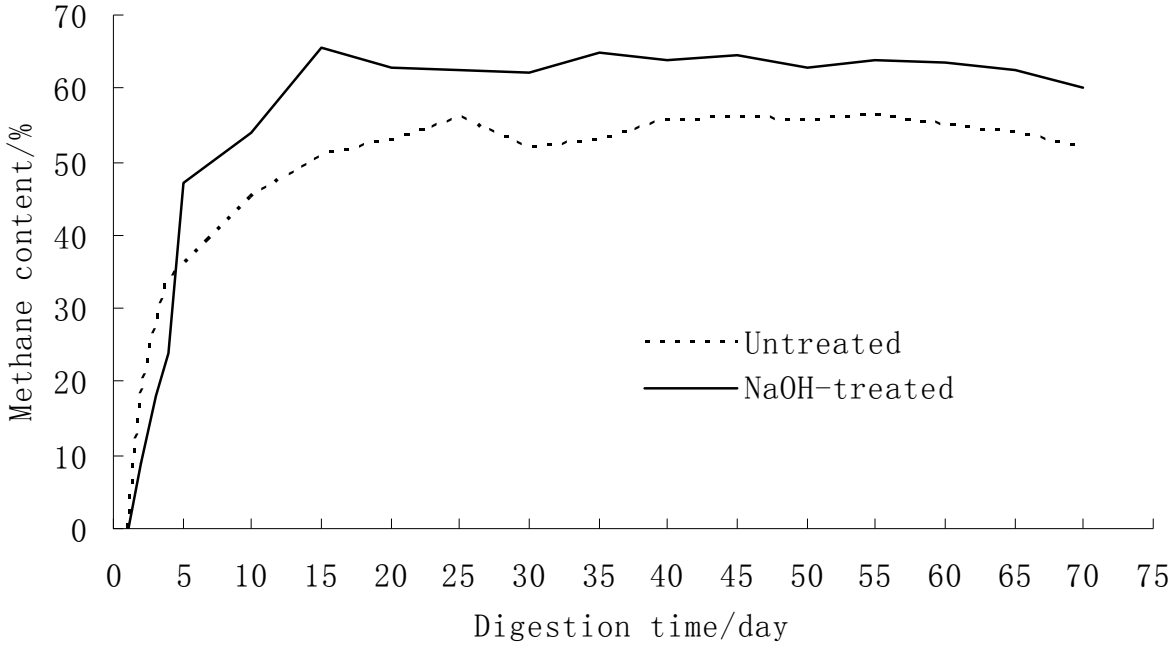


Fig.6 Comparison on methane content for untreated and NaOH-treated

(3)Optimized operational parameters

DT_{90} --Digestion Time

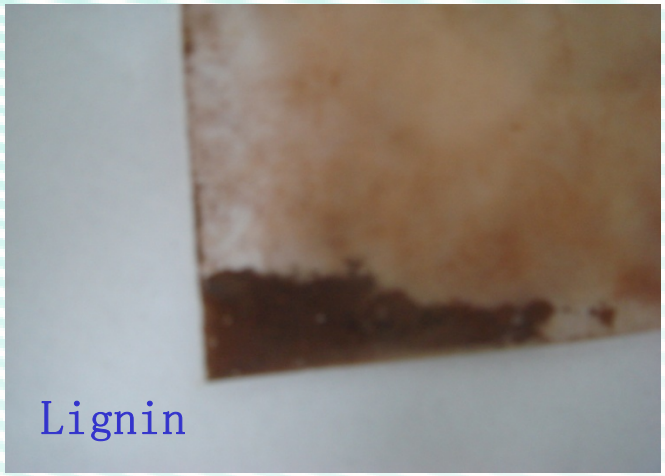
(90% total biogas production)

Loading rate/$g.l^{-1}$	35	50	65	80
DT for Untreated /d	53	56	58	71
DT for treated/d	29	39	44	38
Time reduced/d	24	17	14	33
Production efficiency or capacity increased/%	45.3	30.4	24.1	46.5

Table 3 DT_{90} for untreated and treated corn stovers at four loading rates

(3)Optimized operational parameters

- Extraction and purification of cellulose, hemicellulose and lignin



4. Demonstration-Shandong

9 reactors with total capacity of 450 m^3 each, are able to provide cooking energy for 100families.

4. Demonstration-Shandong


25.12.2004


20.10.2005


储
气
罐
20.10.2005


10.11.2005

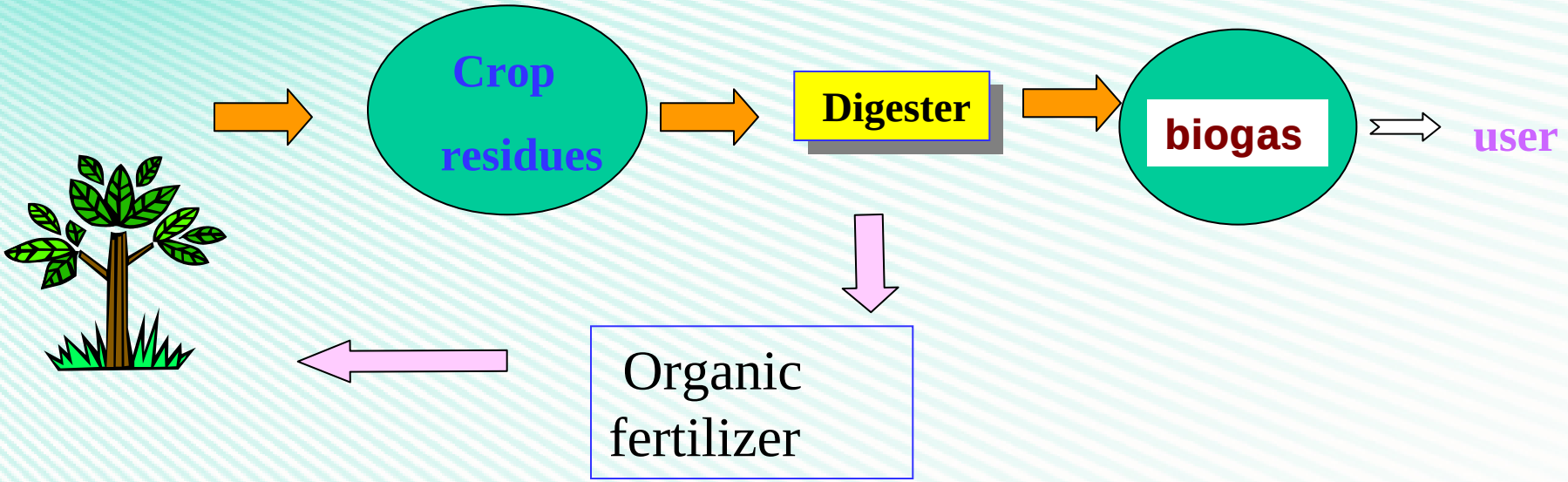

20.10.2005


20.10.2005

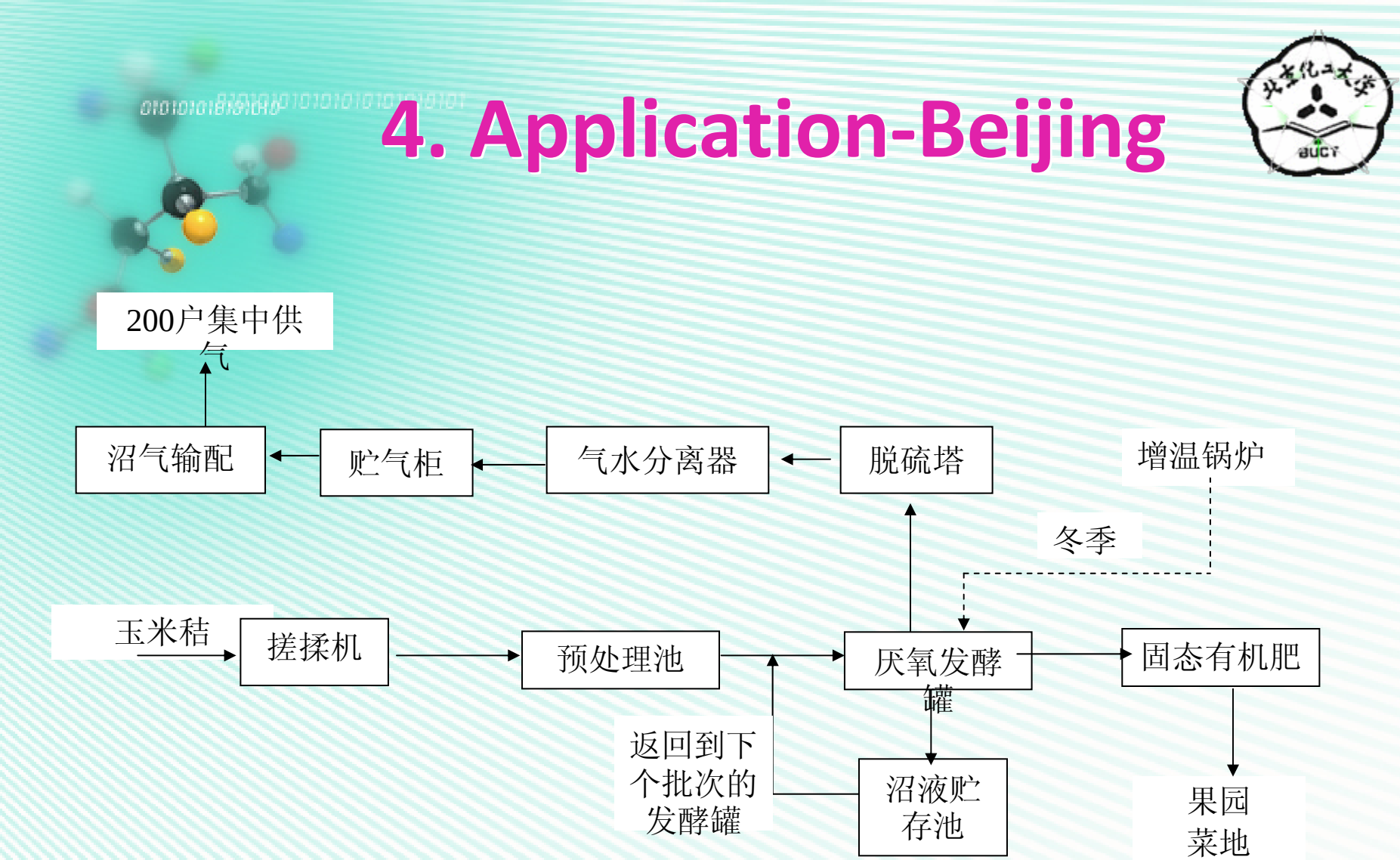

20.10.2005


20.10.2005

Ecological System



4. Application-Beijing



Flow chart of biogas production from crop residues

4. Application-Beijing

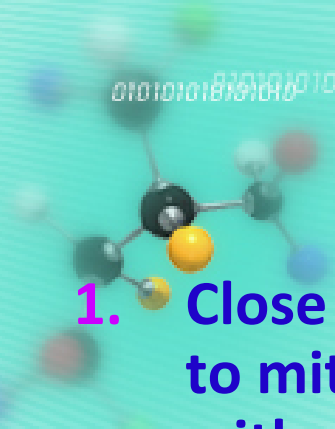
4 reactors with capacity of 1000 m^3 total, are able to provide cooking energy for 300families.

4. Application-Beijing

4. Application-Beijing

Desulfiding and dewatering

4. Application-Beijing



5. Conclusions

1. Close attentions need to be paid to crop residues in order to mitigate increasing environmental problems (CO2) with crop problems as well as use biomass resources for bioenergy production.
2. Pretreatment, specifically designed bioreactor, and optimized operation parameters are key technologies , which need to be developed in order to efficiently convert crop residues into biogas.
3. Feedstock for biogas production will be solved effectively by using crop residues.

李秀金

北京化工大学环境科学与工程系

电话：13661070453