# **CHANIA 2023**

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Room 3 SESSION XV Waste Valorization II 15.30-15.45 22 Jun 2023

Lignin Valorization to Polyhydroxyalkanoates (PHA) Assisted by Adding Volatile Fatty Acids

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### **Sources of lignin and treatment**

#### Source 1: Biorefinery residue

#### Source 2: Paper industrial waste

Second abundant polymer





 Lignin valorization is ignored in biorefinery

Ragauskas, A. J. et al.. Science 344, 1246843 (2014)

- Lignin production of 70 Mt/year globally
- 2 % are sold, others burnt

- Aromatic heteropolymer
- Recalcitrant to depolymerize
- Heterogenous monomers, dimers

### **Catabolism of lignin/aromatics to biofuels**

#### Tandem lignin depolymerization and bioconversion



Linger, J. G. *et al. PNAS*, 2014, *111* (33), 12013–12018. Salvachúa, D. *et al. PNAS* 2020, *117* (17), 9302–9310.

Background Results & discussion Conclusion Acknowledgement

### **Catabolism of lignin/aromatics to biofuels**



Salvachúa, D. *et al. Green Chem.* 17, 4951–4967 (2015). Elmore, J. R. *et al. Nat Commun.* 12, 2261 (2021).

### **1. N-tunable lignin bioconversion**

#### 1) N-rich condition:



- initial biomass not impacted lignin degradation extent ~ 35 %
- high cell density decreased metabolic flux toward biomass growth

### **1. N-tunable lignin bioconversion**

#### 2) N-limited condition:



- initial biomass improved lignin degradation
- high cell density slowed bacterial growth (N consumption)
- high initial biomass & N-limited condition favored higher PHA

#### **2. How to cultivate high initial biomass**

Limitation of using lignin as sole carbon sources

Effect of lignin con. on bacterial growth at low N condition



Search for easier-utilized carbon sources!

### **2. How to cultivate high initial biomass**

#### Search for easier-utilized carbon sources – cellulose/hemicellulose derived VFA



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#### **3. Introduction of VFA into lignin bioconversion**

Initial biomass cultivated using LB, VFA or lignin as carbon source



### **3. Introduction of VFA into lignin bioconversion**



Lignin	VFA additive	PHA yield (g/L)	Yield synergy
1.25 g/L	-	0.042	
	+	0.20	+23%
2.5 g/L	-	0.10	
	+	0.29	+32%
5.0 g/L	-	0.24	
	+	0.43	+19%
7.5 g/L	-	0.28	
	+	0.46	+15%
Sole VFA		0.12	

- VFA improved low con. lignin degradation to 30%
- synergy with VFA additive for PHA production

### **3. Introduction of VFA into lignin bioconversion**



- Fed-batch can avoid toxicity of acetate and cultivate high biomass with VFA
- Higher initial biomass can improve lignin degradation to 30%
- Synergy with VFA additive for PHA production

### 7. Conclusion and perspectives

#### **Conclusion:**



#### Limitation & perspectives:

- How to treat undiluted lignin stream (30-60 g/L)?
- Efficient lignin depolymerization, which is mild to subsequent bioconversion
- Recovery of HMW lignin after fermentation for other application, like materials

### Acknowledgement



## **Thank You!**

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