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APEC
Advanced Biohydrogen Newsletter

The food security, climate change, energy security and interlinked challenges for the APEC region.

Contents

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Main Story

§ Introduction to APEC Research Network for Advanced Biohydrogen Technology §

The 2008 APEC Leaders Meeting in Peru has highlighted the food security, climate change, energy security and clean development as the fundamental and interlinked challenges for the APEC region. Nevertheless, by using the advanced biohydrogen technology to convert the agricultural wastes into hydrogen which could be a possible solution for these challenges.

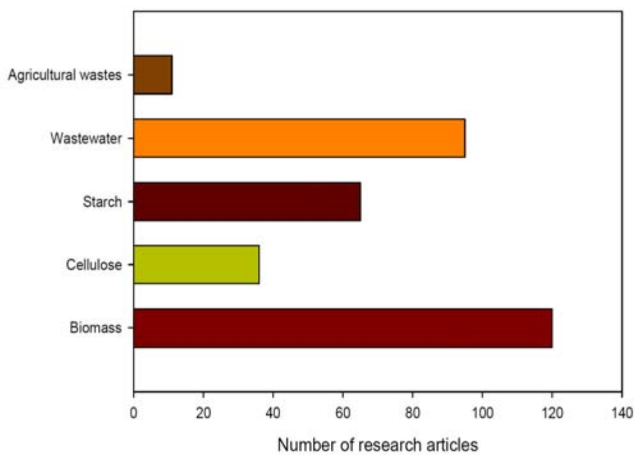
The proposal of the 「APEC Research Network for Advanced Biohydrogen Technology」 has been officially approved at APEC 37th Industrial Science and Technology Working Group (ISTWG) Meeting held on Sept. 24-26, 2009 in Suzhou, China. This frontier project is oriented to set up a scientific research network through regional collaboration. The aims are to develop new generation non-food feedstock biohydrogen technologies, to organize a platform for all the biohydrogen technology experts from APEC member economies to share their research achievement generated from a pilot research center in Chinese Taipei. The expected outcome of APEC research network for advanced biohydrogen technology will meets the APEC Leaders' Declaration because it aims to produce green energy to resolve the issues of environmental protection and energy security, and slow down the climate change by using biomass resources instead of fossil fuel to reduce CO_2 emission. The biomass especially in agricultural waste which are abundant in the APEC member economies.

The key objectives of this project will be achieved to set up an APEC research center for advanced biohydrogen technology; to develop the advanced technology of non-food feedstock biohydrogen production; to innovate a high rate biohydrogen production system, including bacterial screening, cultivation, bioreactor design, scale-up technology, biogas purification, applications of high value-added liquid products, reuse of organic wastes; to offer facilities in the research center, such as laboratories open to the students from the APEC member economies for short-term study or visiting; to set up a website, to organize a symposium for biohydrogen technology experts from the APEC member economies, and to extend and expand the biohydrogen technology to the APEC member economies.

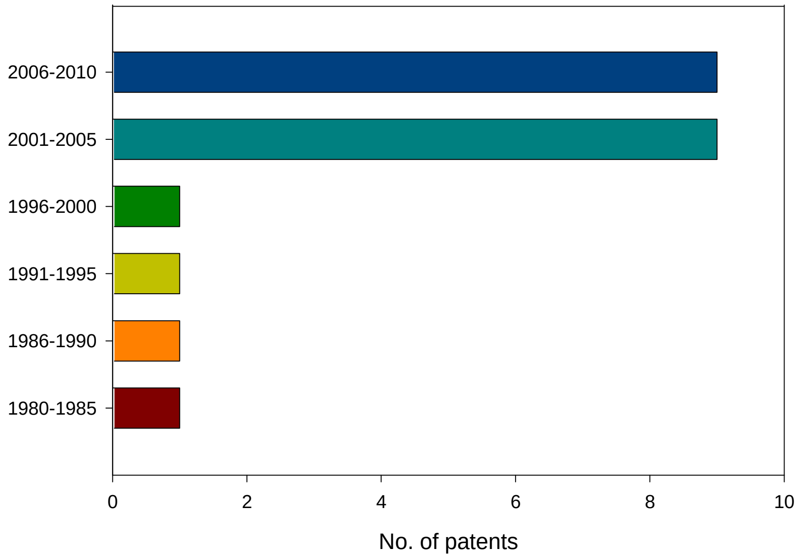
Research Report

§ Publication record on biohydrogen Production from wastes §

Based on the last 5 years records from ISI on different wastes, it is found that nearly 120 original research articles were published on biohydrogen from biomass which include all sources of biological origin. Around 95 articles are published on biohydrogen from wastewaters. A low number of articles are published on biohydrogen from cellulose (36), starch (65) and agricultural wastes (11). From the ISI record search results on biohydrogen production from different sources, it is well understood that more research is needed to be done on biohydrogen production from agricultural wastes and cellulosic materials.

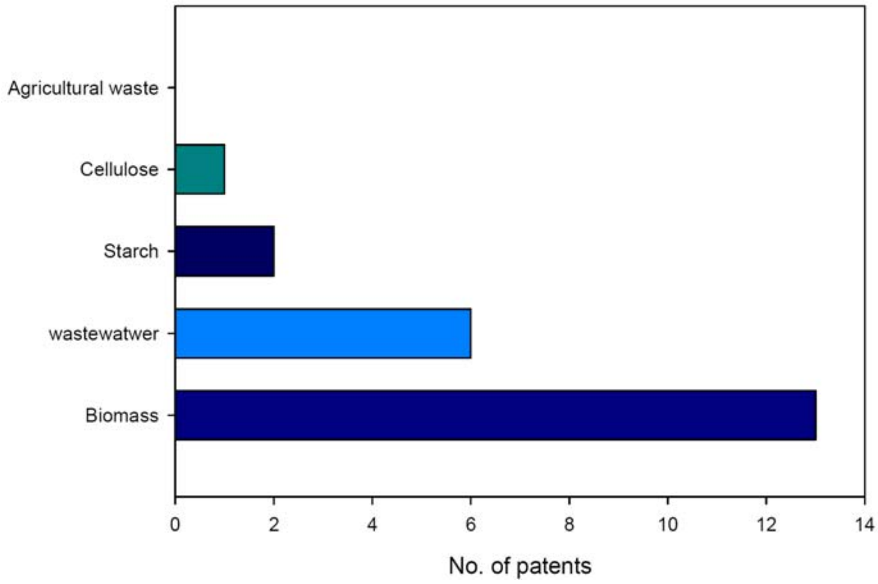


§ Year wise patents record on biohydrogen production from wastes §



When we observe the patents on hydrogen production through biological methods for the last 30 years from different kinds of wastes they are increasing in their number. The number of patents increased from one (1980-85) to nine in 2006-2010. This trend shows that the importance has been increasing for the biohydrogen production according to time. In the coming years we can have more patents which focus on commercially viable technology for biohydrogen generation along with the waste reduction by using different kinds of wastes

§ Patents record on biohydrogen production from wastes §



The number of patents on hydrogen production from individual wastes like biomass, wastewater, starch, cellulose and agricultural waste indicates that the number of patents on the hydrogen production from biomass is more when compared to the other wastes. For agricultural wastes no patents are available. Biohydrogen generation from agricultural wastes is slowly gearing up and there is a lot of scope to work on these wastes and get patents in this area. We can also concentrate more on generating biohydrogen from various industrial wastewaters which not only helps in getting renewable energy source but also helps in the reduction of the toxic effects of the wastewater on the receiving land or water bodies.

§ Biohydrogen Production From Ricebran De-oiled Wastewater by Dark Fermentation §

Authors: Gopalakrishnan K, Sivaramakrishna D, Hima bindu V, Department of Environment, JNTU, Hyderabad (Adopted from MS Dissertation submitted to VIT University, Tamilnadu)

Biohydrogen will play important roles for future energy economy as clean, CO2 neutral and environmental friendly energy. Among the hydrogen production methods, the most promising and environment friendly method seems to be dark fermentation from organic wastes as it combines the energy (hydrogen) generation with waste treatment. The current study focused on the identification of new substrate for biohydrogen production and optimizing the environmental parameters and isolation of hydrogen producing microorganisms. Much of the work has been done on the hydrogen production using different microbes from different substrates. Efforts have been made to optimize the hydrogen production through degradation of carbohydrates as a substrate by inhibition of methanogenesis. Extensive research was carried out for hydrogen production using various waste materials and wastewater from industrial process such as probiotic wastewater, food and domestic wastewaters and citric acid wastewater. Use of industrial wastewater as substrate facilitates both treatment and renewable extraction of hydrogen (clean gas) simultaneously. However, no previous study has been reported on the use of rice bran de-oiled wastewater as substrate for the production of hydrogen. The aim of the present study, therefore, was to evaluate anaerobic biohydrogen production process using rice bran de-oiled wastewater, which is a live carbohydrate rich source for biohydrogen production and the environmental parameters such as pH, Temperature and substrate concentration also monitored. The anaerobic batch experiments were carried out in magnetically stirred continuous 5l batch reactor with a working volume capacity of 3l and maintaining a constant temperature of 54±3˚C, The pH of the mixed liquor in the reactor was adjusted by using 2N HCl and 2N NaOH solutions. Following this investigation, the amount of yeast extract was optimized for hydrogen production over a range of 0.25 – 2.5g/l of total nitrogen and maximum hydrogen production of 670ml was observed at pH 6 at the temperature of 57 ˚C for a duration of 60 minutes has shown maximum VFA production of 4200mg/L. Ultimately at the pH of 6 and the temperature of thermophile the Biohydrogen production was high while the monosaccharide such as glucose and sucrose were mainly used as substrate. Isolation of hydrogen producing organisms has been carried out by using specific medium (AB medium) and the organism has grown and sub cultured for further studies. The biofilm formed on the surfaces of the supporting media was subjected to the SEM (Scanning Electron Microscope) analysis at different magnifications. SEM images of the anaerobic mixed cultures acquired from the experiments visualized only rod shaped heterogeneous bacterial populations of hydrogen producing bacteria at the pH 6, which has revealed that pretreatment has done properly and the combined treatment has shown higher production.

Key words: Biohydrogen, Dark fermentation, Rice bran de-oiled wastewater, Batch reactor, VFA, AB medium, SEM

§Phase holdups and microbial community in high-rate fermentative hydrogen bioreactors§

Authors: BioH_2 research team of Feng Chia University. Update by Dr. Chen-Yeon Chu

Phase holdups play an important role in high rate hydrogen production in an anaerobic fermentative reactor, especially in understanding biomass content, biogas flow and distribution that significantly affect the flow regimes change in the reactor. In the present study three-phase hydrogen producing reactor with different configurations were tested to investigate the phase holdups phenomenon and microbial community. It was found that the major fatty acids produced from the reactors were acetate and butyrate (HBu), accounting for 74.4-93.5% of total soluble microbial products (SMP). When the HRT was shortened from 8 to 1 h, the HBu was the dominant acid product among the soluble metabolites and the ratio of Ethanol/SMP was lower than 15.1. Moreover, the gas holdup (ε_g) and solid holdup (ε_s) increased but liquid holdup (ε_l) decreased when the HRT was shortened. When the HRT was down to 1 h an increase in gas and solid holdups were noted. The gas holdups (ε_g) increased in the range of 0.30-0.34, and the solid holdups (ε_s) increased in the range of 0.32-0.34, which mean that the values of liquid holdups in high-rate fermentative hydrogen bioreactors could be decreased in the range of 0.38-0.32. Moreover, the empiricacorrelations of this study were satisfactory to predict the phase holdups in a dark-fermentation biohydrogen system. PCR-DGGE analysis revealed that bioreactor hydrodynamics under different HRTs significantly affects the occurrence of *Streptococcus* sp. and *Bacillus* sp. which mainly promotes granulation and retains high yielding hydrogen producing *Clostridium* sp. through their exopolysaccharides production. SEM results showed three dominant bacterial species namely *Clostridium pasteurianum*, *Streptococcus* sp. and *Propionibacterium* sp. in the bioreactors. (This abstract was adopted from the accepted paper in International Journal of Hydrogen Energy, 2010)

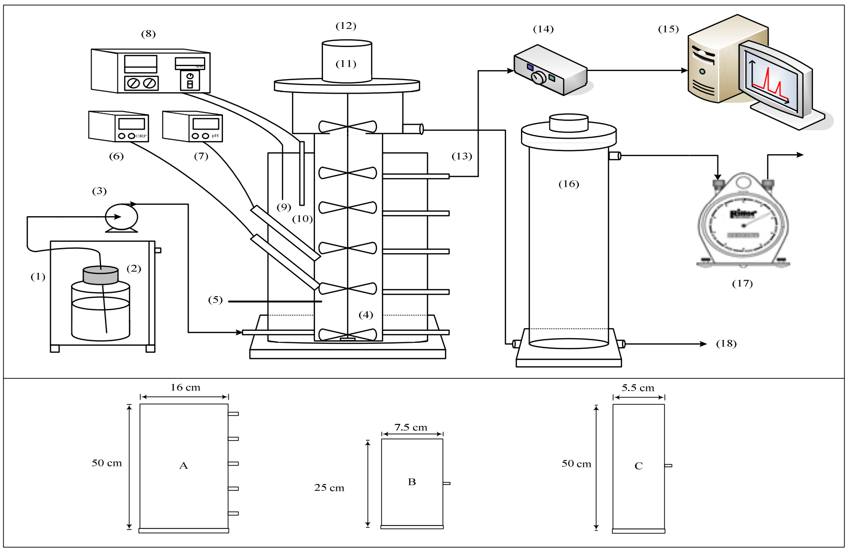


Figure 1: Schematic diagram of the continuously stirred anaerobic bioreactors (A:H 50.0 cm, ID 16.0 cm; B: H 25.0 cm, ID 7.5 cm and C: H 50.0 cm, ID 5.5 cm). (1) Cold chamber, (2) Nutrient tank, (3) Peristaltic pump, (4) Stirring baffles, (5) Thermocouple probe, (6) ORP controller, (7) pH controller, (8) Controller of temperature and rotational speed, (9) Temperature sensor, (10) Heater, (11) Agitator, (12) Main body of the Bioreactor A, B and C, (13) Pressure tap, (14) Science Workshop PASCO 750 interface, (15) PC, (16) Gas-liquid separator, (17) Wet gas meter,(18) Effluents of waste liquid

Special Column

§ Steering Committee Meeting Report §

The 2010 steering committee meeting and workshop of APEC research network for advanced biohydrogen technology

- **Date and Venue**

- February 3, 2010, Feng Chia University, Taichung, Chinese Taipei

- **Activities**

- More than 150 participants have joined for the workshop from private sectors, research institutes & academies of all over the world.
- A Visit to biohydrogen production pilot plant and laboratory.
- Exchange of research results of biohydrogen technologies to enrich their knowledge.

- **Member list of steering committee of APEC Research network for advanced biohydrogen technology**

Economies	Name	Gender
Chinese Taipei (Overseer)	Prof. Chiu-Yue, Lin	M
Canada(EGNRET)	Dr. Mark Stumborg	M
China	Prof. Nan-qi Ren	M
Indonesia	Dr. Dwi Susilaningshih	F
Japan	Prof. Jun Miyake	M
Korea	Dr. Mi-Sun Kim	F
Thailand (EGNRET)	Ms. Peesamai Jenvanitpanjakul	F
Thailand	Prof. Alissara Reungsang	F
Chinese Taipei (EWG)	Mr. Chen	M
Chinese Taipei (EGNRET)	Dr. Hom-Ti Lee	M
Chinese Taipei	Prof. Shu-Yii Wu	M
Chinese Taipei	Prof. Jo-Shu Chang	M
Chinese Taipei	Prof. Duu-Jong Lee	M