Present Situations and Prospects on Bioethanol and Biodiesel in Relation to Kyoto Protocol

Shiro Saka
Graduate School of Energy Science, Kyoto University
Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501 Japan
Tel/Fax: +81-75-753-4738, saka@energy.kyoto-u.ac.jp

In the current worldwide depletion of fossil resources and the global warming, special attention has been directed toward utilization of biomass for production of energy and chemicals. Therefore, renewable biofuels are getting important as alternatives of fossil fuels for solving our energy and environmental problems. Particularly, the conversion of mollasses, starch and lignocellulosics to bioethanol or plant oils/animal fats to biodiesel (fatty acid methyl esters) is one of the main concerns in bioenergy research and development for the reduction of greenhouse gas (GHG) emissions.

For bioethanol production, the several research projects are undergoing in Japan on lignocellulosics-to-bioethanol for industrial applications by the concentrated sulfuric acid and diluted sulfuric acid processes, and for academic application by supercritical water (>374°C, >22.1MPa) technology.

For biodiesel production, several research projects are also undergoing for plant oils and animal fats such as rapeseed oil and its waste, palm oil (*Elaeis guineens*), tung tree oil (e.g, *Jatropha curcas*), etc. Conversion of these oils/fats to biodiesel is worldwide made by the alkaline catalyst method. However, this process has some drawbacks and limitations such as formation of the saponified products, the negative effect in reaction by the presence of water which may hinder a maximum utilization of waste vegetable oils and animal fats. For this circumstance, a catalyst-free method for biodiesel production has been developed by employing supercritical methanol.

To fulfill the target in Japan for Kyoto Protocol (Table 1), the present situations and prospects are, therefore, introduced on demand and supply of bioethanol, particularly in relation with Brazilian bioethanol, and biodiesel in relation with its raw materials for biodiesel production.

Table 1 Kyoto Protocol (The Third Conference of the Parties (COP3) in Kyoto in Dec. 1997)

1. Year period:	2008-2012
2. Level:	At least 5% reduction in industrialized countries for GHG emissions, relative to emissions in 1990. Japan: 6%, EU: 8%
3. Gas for target:	6 gases (CO_2, CH_4, N_2O, HFC, PFC, SF_6)
4. Forestry activities:	CO_2 fixation by afforestation and reforestation can be counted for reduction of GHG after 1990
5. Flexibility:	・Emission trading ・Joint implementation ・Clean development mechanism

1) Bioethanol

Different from some other Asian countries, Japan and Korea do not have much feedstock available for ethanol production such as mollases and starch. Therefore, lignocellulosics is an important raw material for ethanol production and its conversion to ethanol is one of the main concerns in bioenergy research and development in Japan to fulfill the target in Kyoto Protocol for the reduction of greenhouse gas emissions. According to our recent investigation, about 30×10^6 tons of lignocellulosics are not used efficiently in Japan and abandoned, from which about 8.4BL ethanol can be produced.

Under these conditions in Japan, the several research projects on lignocellulosics-to-ethanol have been undergoing for industrial applications such as the concentrated sulfuric acid process from Arkenol Inc., USA (Fig. 1) and the dilute sulfuric acid process from BC International Corp., USA, both having been in the NEDO technology development projects for bioenergy conversion study. On the other hand, for one of the academic applications, supercritical water (>374°C, >22.1MPa) technology has recently received increasing attentions. In our laboratory, therefore, supercritical water treatment was made with lignocellulosics to obtain sugars which are then biologically fermented into ethanol and useful chemicals (Fig. 2).

To know the current situations on ethanol utilization, we have made a detailed survey on its demand and supply in Asian countries such as Japan, Korea, China and Thailand. As a result, it was clarified that ethanol market has been developed and commercialized already in China and Thailand. It was found to be due to a sudden increase in the crude oil price and recent motorization progressed by an economic development, together with a plentiful feedstock available in these developing countries.

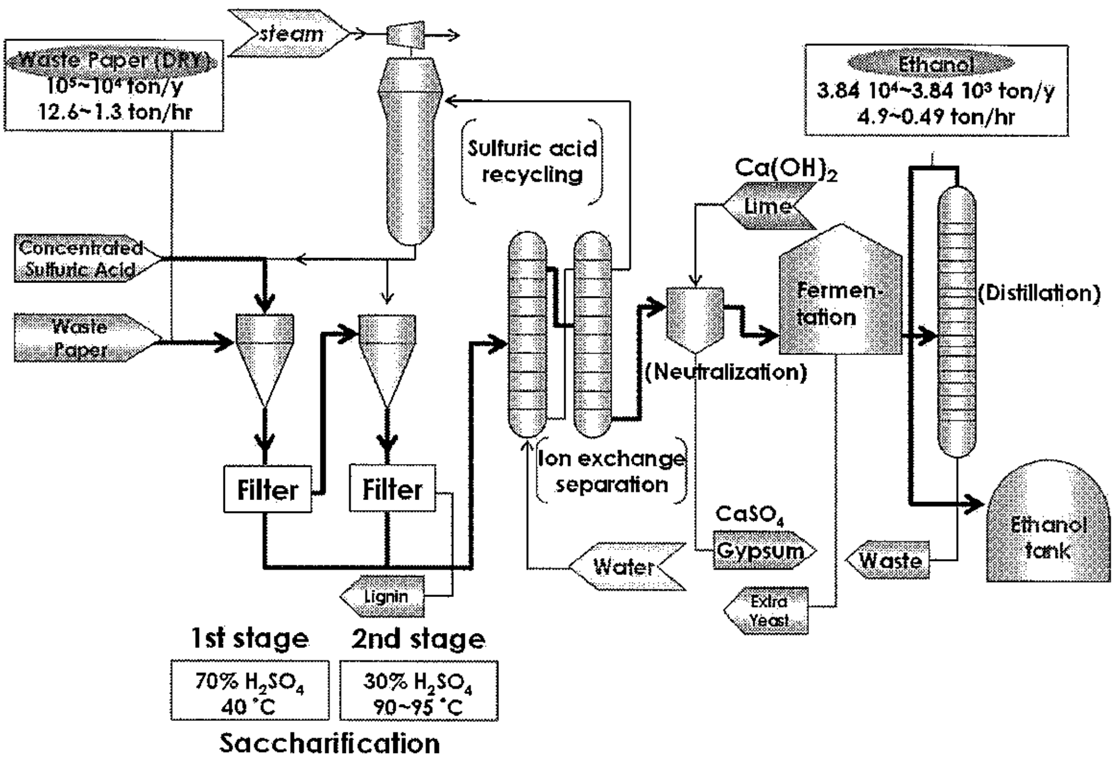

Fig. 1 Concentrated sulfuric acid process for ethanol production from lignocellulosics (Arkenol Process)

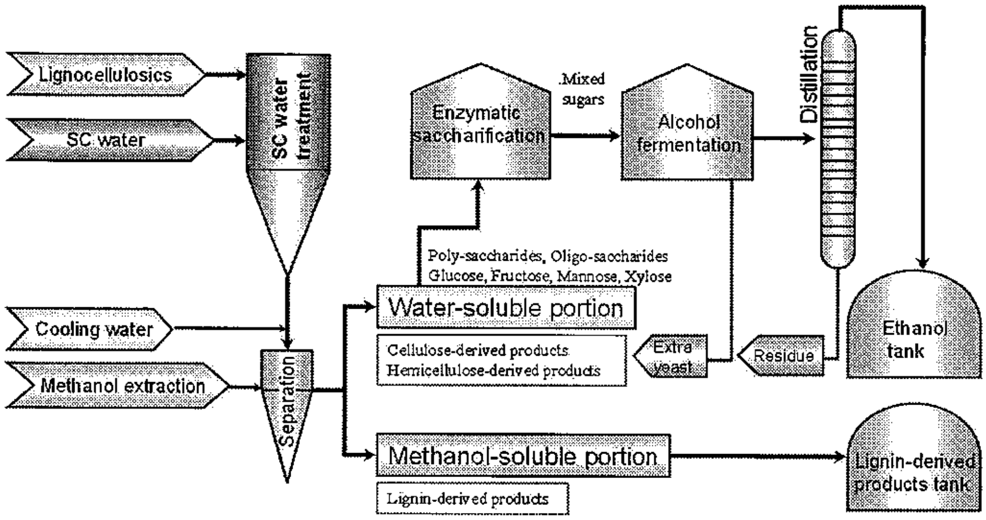

Fig. 2 Supercritical water process for ethanol production from lignocellulosics (Kyoto University Process)

In Japan, gasoline was agreed to be 3% mixed with bioethanol (E3), because the legislation of alcohol was revised and alcohol business was liberalized since 2006. In case of 3% ethanol blending, 1.8BL of ethanol per year will be required, because we consume annually about 60BL of gasoline. From this, we can expect to reduce 0.3% of the CO_2 emission for the obligatory 6% reduction in Kyoto Protocol. Utilization of ethanol is, however, under consideration through the empirical car testing. In addition, due to some problems by the increased vapor pressure and phase separation of the mixture, ethyl tertiary butyl ether (ETBE) is also considered as an additive to gasoline.

In Korea, a progress is only for testing production of ethanol from the imported grains, and not much work has been done yet.

In China, ethanol production has been developed in the north-east granary region since 2000 with using maize mainly. This is because the urban area is air-polluted and economical development is eager to be made in the rural area by the efficient utilization of grains, whereas in Thailand, ethanol production has been progressed since 2000 to stimulate local economics in rural district, and now ethanol, which is produced from molasses, has been sold in a vicinity of Bangkok so as to decrease the energy-related governmental budget through their own national biofuels introduced. In the near future, they are expecting a large-scale ethanol production on the sugarcane industry basis.

Based on these lines of information, the future trends and prospects on ethanol utilization in Asian countries will be presented, including the role of emission targets and the possible opportunities for the Asian ethanol industry.

2) Biodiesel

Biodiesel fuel is one of the most promising bioenergies, which can be produced for an alternative for fossil diesel from plant oils/animal fats through transesterification. Current commercial process for biodiesel production involves the use of alkali catalyst, followed by the removal of the catalyst and saponified products from free fatty acids. In addition, water-containing waste oils/fats depress the catalyst activity. These cannot allow the low-quality feedstock such as waste cooking oil and waste industrial oil. For solving these problems, our research group has developed non-catalytic biodiesel production method by supercritical methanol technology (>239°C, >8.09MPa).

With various kinds of biodiesel production methods, biodiesel fuel has been produced worldwide and its utilization promoted, with increasing concern to the environmental issues such as global warming and air pollution. For further dissemination, availability of oil/fat feedstocks is getting more important, thus, they should be efficiently utilized, especially in Japan. Therefore, available amount of waste oils/fats has been estimated as a raw material for biodiesel production.

Fig. 3 depicts domestic demand of edible oils/fats and estimation of waste oils and fats in Japan. As a result of refining, less than 30 thousand tons of dark oil emerges. Waste oils discarded from oils/fats products manufacturer, food manufacturing industry and food service industry are 20, 80 and 200 thousand tons, respectively. From households, 120~240 thousand tons of used cooking oils emerge. Summation of these waste oils/fats reaches 450~570 thousand tons. It should be noted that approximately half of them, 150~270 thousand tons are uncollected and just burned as garbage. If these uncollected waste oils and dark oil are used as a raw material for biodiesel, they becomes approximately 0.3 BL of alternative fuel for fossil one, which may contribute to approximately 0.8% reduction of annual fossil diesel fuel consumption.

This amount is not sufficient. For example, if fossil diesel is agreed to be 3% mixed with biodiesel (B3) as in bioethanol for gasoline, 1.2BL of biodiesel per year will be required, because we consume annually about 40BL of fossil diesel. From this, we can expect to reduce 0.2% of the CO_2 emission for the obligatory 6% reduction in Kyoto Protocol. To do so, we need additionally at least 0.9BL (=1.2BL - 0.3BL) of biodiesel. For this difference, we have to collect a raw materials from abroad, particularly from South-Eastern Asia, of palm oil, palm kernel oil etc.

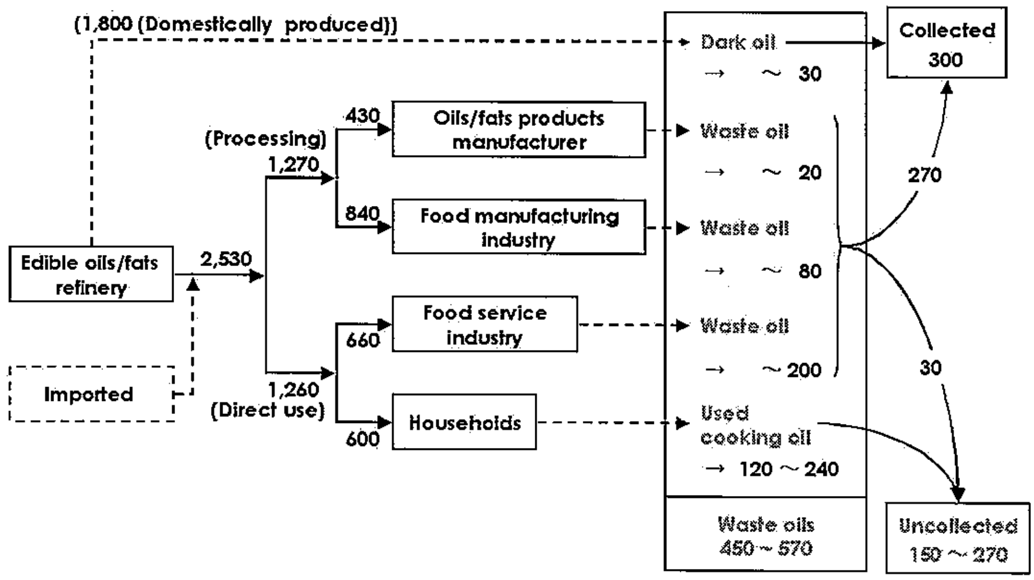

Fig. 3 Estimation of waste oils/fats discarded in Japan (1,000t)

3) Concluding Remarks

The present situations and prospects of the bioethanol and biodiesel were presented, and it was clarified that if E3 and B3 are introduced to gasoline and diesel fuels, respectively, in Japan, 0.5% (= 0.3% + 0.2%) reduction of the CO_2 emission can be achieved, and if E10 and B10 are adopted, 1.7% (=1.0% + 0.7%) will be resulted for the obligatory 6% reduction in Kyoto Protocol. The achieved number is not high. However, the utilization of these biofuels will be essential to improve and clean up our environments and restrain the global warming for the future.

CV

SAKA Shiro

Professor Shiro Saka who graduated from Kyoto University in 1975 has studied and gained a Ph. D. in Wood Science from North Carolina State University in 1980. In 1988 he became an Associate Professor in the Department of Wood Science & Technology, Faculty of Agriculture at Kyoto University, and in 1996 he became a Professor in the Department of Socio-Environmental Energy Science, Graduate School of Energy Science, Kyoto University.

He has produced over 120 research papers, about 180 international conference proceedings, 54 books and been awarded 15 patents.

Current projects include research on biofuels through thermochemical conversions of biomass to bioethanol by supercritical water and on plant oils and animal fats to biodiesel by supercritical methanol, and further related research of biomass to biofuels and chemicals..

He is currently a task leader of bioenergy group in Kyoto University 21COE Program "Establishment of COE on Sustainable Energy System" .

He@ is also presently the President of Biomass Division, Japan Institute of Energy, Japan and Chairman of the Planning Division, The Society of Materials Science, Japan, and will be the Editor of the Journals of Wood Science and Mokuzai Gakkaishi, The Japan Wood Research Society.