4-5 Metal Oxides Become Active Catalysts When Irradiated by Electron-Beams!

— Enhancement of the Oxidation of Organic Substances with Electron-Beam Irradiated γ-Alumina —

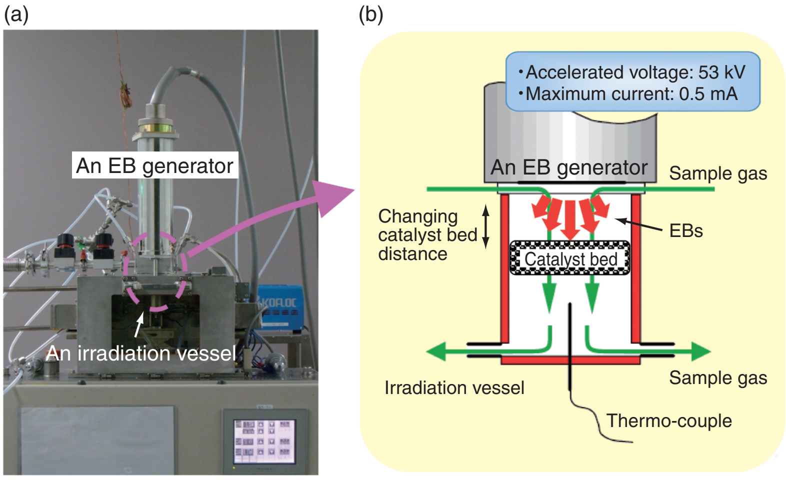

Fig.4-11 (a): An EB irradiation/catalyst system (external view), (b): an irradiation vessel for a gas stream (interior view)
This system consists of an EB generator, an irradiation vessel, catalysts, and gas analyzers. A sample gas containing organic substances was irradiated with EBs and then passed through a catalyst bed. The energy directly delivered to the catalyst bed was changed from zero to 50% of total EB energy by placing it at different distances from an EB irradiation window.

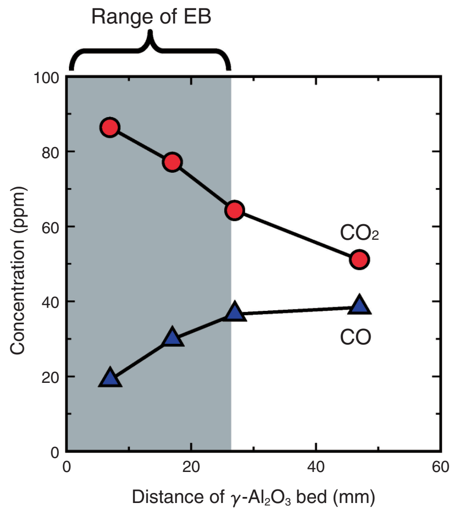

Fig.4-12 The concentrations of CO_2 and CO in 50-ppm xylene/air mixture irradiated at a dose of 10 kGy when γ-Al_2O_3 bed was placed at various distances
10-kGy EB irradiation without a γ-Al_2O_3 bed produced 28.9-ppmv CO_2 and 38.5-ppmv CO. Placement of a γ-Al_2O_3 bed at a distance of 7mm caused higher production of CO_2 with less CO production.

Emission of various organic substances from painting factories causes photochemical smog. We have developed a gas purification system that can oxidize organic substances into CO_2 and CO using electron beam (EB) irradiation. In this treatment, such organic substances should be preferentially oxidized into CO_2 without producing toxic CO. We have recently focused on the development of EB use with catalysts for this purpose and found that a γ-alumina (γ-Al_2O_3) bed exhibited the best catalytic activity together with an electron accelerator, especially when its surface is directly irradiated with EBs.

The EB irradiation involved a variety of chemical reactions. For the understanding of complicated radiation-induced catalytic reactions, we manufactured an EB irradiation/catalyst system that can irradiate a sample gas in the presence of a catalyst bed placed at various distances from an EB-irradiation window. (Fig.4-11) The catalytic oxidation of *o*-xylene in air was studied using a γ-Al_2O_3 bed as a catalyst. The results were summarized as follows;

(1) Higher CO_2 concentration was obtained by an EB/catalytic treatment.
(2) Irradiation products of xylene oxidized exclusively into CO_2 over the γ-Al_2O_3 surface.
(3) The formation of CO_2 was enhanced and the production of toxic CO was suppressed when a γ-Al_2O_3 bed was directly irradiated with EBs, namely placed in an EB-induced plasma. (Fig.4-12).

Our previous studies demonstrated that the placement of common catalysts such as TiO_2 and MnO_2 in an EB-irradiation space led to the decrease of CO_2 concentration due to suppression of gas-phase oxidation reactions. On the other hand, the placement of γ-Al_2O_3 in the EB-irradiation space caused higher-concentration of CO_2. Such catalytic oxidation activity was found to be due to the exclusive oxidation of the irradiation products of xylene over EB-irradiating γ-Al_2O_3 surface into CO_2.

In general, metal oxides, such as γ-Al_2O_3, are made into chemical catalysts by loading noble metals on the surface. The present results are important not only for an EB-gas purification technology but also for production of a new catalyst which does not load any noble-metals.

Reference

Hakoda, T. et al., Oxidation of Xylene and Its Irradiation Byproducts Using an Electron-Beam Irradiating a γ-Al_2O_3 Bed, Journal of Physics D: Applied Physics, vol.41, no.15, 2008, p.155202-1-155202-7.