CHAPTER II

LITERATURE REVIEW

2.1 Silver Catalyst and Oxygen Adsorption Mechanism

Silver is known for its unique catalytic properties in gaseous phase oxidation reactions, particularly ethylene oxidation reaction. The effect of silver particle size on the reaction rate is in the opposite direction to other catalysts. The catalytic properties of Ag change sharply for particles that are abnormally large (hundreds of °A) is quite surprising since the properties of such abnormally large particles should not differ from those of the bulk (Goncharova et al, 1995). Numerous authors observed a catalytic size effect of silver within the 100-1000 °A range and explained it by the changes in the surface structure, particle morphology, support effect and etc. (Harriot, 1971). The influence of these factors as well as a broad particle size distribution result in a wide range of both size effect values and crystal sizes for which the changes in catalytic activity can be particularly sharp. Lee et al. (1989) studied supported silver catalysts and found a three-fold increase in the reaction rate with increasing silver particle sizes within 150-400 °A. This was explained by the decrease of the proportion of small particles (< 100 °A). These small particles are known to exhibit no catalytic activity. As a rule, this was assumed to relate to the over oxidation of small Ag particles to inactive Ag_2O. Some studies provided the useful finding that Ag particles, in particular the small ones, can migrate over the support surface.

Lee et al. (1989) concluded that the specific activity of silver could vary by as much as a factor of 50 depending on the support employed. Moreover, the influence of metal crystallite size was also found to depend on the carrier employed. They also investigated that the low or zero apparent selectivity of silver supported on various carriers was primarily due to isomerization and oxidation of ethylene oxide on sites supplied by the support material. All conventional and non-conventional carriers examined exhibited activity towards ethylene oxide isomerization and combustion, with exception of $\propto$-alumina.

Cheng and Clearfield (1985), using a non-conventional support material, zirconium phosphate, observed a decrease in activity of catalyst when the surface area of the support increased.

Commercial silver catalysts, commonly, consist of 10-15 wt. % silver on low surface area $\propto$-alumina. High metal content is necessary to provide large active surface area, albeit with a very low degree of dispersion. However, if a higher degree of dispersion of the metal could be achieved, the same active area could be obtained with significantly smaller amount of silver. As a consequence of this, the precious metal could be utilized more efficiently and the process would become more economical. A high degree of metal dispersion can usually be achieved by employing high surface area supports (Bulushev et al, 1995).

One of the most important roles of silver catalyst towards ethylene oxidation reaction is its mechanism of oxygen adsorption. Because of the importance of the mechanism, the oxygen complexes adsorbed on silver have been characterized by a wide variety of studies, including calorimetric studies, infrared spectroscopy, isotopic exchange, electron diffraction, and kinetic studies of adsorption rates (Satterfield, 1991). A reaction mechanism commonly advanced is that proposed by Kilty and Sachtler (1974), which is also discussed by Carrá and Forzatti (1977). Basically, diatomic oxygen is proposed to be adsorbed onto a single silver atom. (This molecular oxygen may be somewhat ionic or so called oxygen super-ion (O_2^-.) The mechanism can be written as :

$$O_2 + Ag \text{-------}> O_2^-{}_{(ads)} + Ag^+$$

The ability of silver deposited on alumina in generating oxygen super-ions for water sterilization is in focus. We, basically, believe that this active oxygen can react with organic materials, including bacteria, and shows its oxidizing power on killing bacteria suspended in drinking water.

2.2 Monolith as Selected Support

The structure of monolith is similar to a honeycomb with equally sized and parallel channels which may be square, sinusoidal, triangular, hexagonal, round, and so on. The ceramic honeycomb itself has low surface area, so it is necessary to deposit a high surface area material such as Al_2O_3 onto the channel walls (Heck et al, 1995). This is known as monolith alumina washcoat. Monolith offers a number of advantages over traditional pellet-shaped catalysts. The most important advantage is the low pressure drop associated with high flow rates. Since the monolith has a large open frontal area and with straight parallel channels, it offers less resistance to flow than that of a pellet-type support.

Synthetic cordierite, $2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$, makes up the ceramic monolith, which has some basic properties. The properties may, however, be varied by suppliers. By nature, a monolith has low thermal expansion coefficient of about 10×10^{-7} /°C and its melting point is over 1,300 °C. Because of these properties, it resists cracking from rapid temperature changes. However, the alumina washcoat influences the thermal shock resistance of the monolith because the washcoat can expand more than monolith. This difference must be minimized by slow heating rate in order to maintain good adherence of alumina washcoat on the channel walls (Heck et al, 1995).

2.3 Pathogens and Pathogen Indicators

From the perspective of human use and consumption, the most importance of biological organisms in water are pathogens, those organisms capable of infecting or of transmitting diseases to human. Analysis of water for all pathogens would be very time-consuming. Tests of specific pathogens are usually made only when there is a reason to suspect that those particular organisms are present. Normally, the purity of water is checked using indicator organisms (Peavy et al., 1985).

Most of the pathogens are introduced through fecal contamination of water. Thus, any organism native to the intestinal tract of humans would be a good indicator organism. Composed of several strains of bacteria, principal of which is *Escherichia coli*, *E.coli* (Peavy et al., 1985). Moreover, *E.coli* bacteria is widely studied and the genetics is clear.

2.4 Concept on Testing of Microorganisms

Generally, there are several methods used for testing bacteria in water such as most probable number or MPN technique, membrane filtration technique and plate count method. The membrane filtration technique is a technique that is highly reproducible and is extremely useful in monitoring drinking water and a variety of natural waters. Statistical comparisons of results obtained by the MPN technique show that the membrane filtration technique is more precise (APHA, 1985). In the test, a portion of sample is filtered through a membrane, the pores of which do not exceed 0.45 microns. Bacteria are retained on the filter which is then placed on selective media to promote growth of coliform bacteria while inhibiting growth of other species. The membrane and media are incubated at the appropriate temperature for an appropriate period of time, allowing bacteria to grow into visible colonies that are then counted.