DEGRADATION OF TCDD BY FENTON-LIKE OXIDATION USING STEELER'S DUST

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Introduction

The contamination of soils, groundwater, and industrial wastes by toxic organic compounds remains a widespread problem. Although biological processes are often most favorite for contaminated site remediation, advanced oxidation processes (AOPs) provide an effectiveness of rapid treatment.

The Fenton's reagent refers to a mixture of hydrogen peroxide and ferrous salts, which is an effective oxidant for a wide variety of hazardous organic compounds, including landfill leachates[2], groundwater contaminated with chlorinated compounds[3,4], dry-cleaning organic solvents[1,5], nitro-aromatic compounds[6,7], and PCB congeners[8]. These treatment technologies were due to the reactive hydroxyl radicals generated in an acidic solution by the catalytic decomposition of hydrogen peroxide, in which OH · radicals are among the most reactive oxidants found in aqueous environments

Recently, a Fenton-like reaction using zero-valent iron instead of Fe^{2+} has been found to be effective in degradation of organic compounds in wastewater. In this study, degradation of tetrachlorodibenzo-*p*-dioxin was tried with steeler's dust as the zero-valent iron for Fenton-like reaction.

Materials and method

Materials.

The chemicals were used as follows: 1,2,3,4-TCDD(Accustandard, New Haven, CT), toluene (Merck, Germany), hydrogen peroxide (30%, Merck) and acetone (Merck). All of the aqueous stock solutions were prepared using the deionized water in the reactor. The base solution of 1N NaOH and the acid solution of 1N HCl were sparged with the reactor for pH control. The steeler's dust was obtained from Pohang Iron & Steel Corp. (POSCO), Korea.

Fenton reactor system.

The Fenton-like oxidation reactor was used in a 40 mL vial fitted with PTFE-lined caps. The 1,2,3,4-TCDD contaminated water (20 μg/20mL) was added a mass of 5-10 g of steeler's dust into Fenton reactor. The pH was controlled with sodium hydroxide or hydrochloride solution. The reactions were started by the addition of hydrogen peroxide. All vials were placed on an orbital shaker at 30 ℃ and shaken at 200 rpm. At each sampling time, reaction vials were removed for extraction and analysis of 1,2,3,4-TCDD.

Extraction and analysis.

The liquid-liquid extraction technique was used to extract TCDD with toluene as a solvent. 20 mL of toluene were added to extract in the liquid phase. After the extraction, the upper toluene phase was passed through anhydrous sodium sulfate column to remove any residual water from the toluene phase, then concentrated under vacuum using a rotary evaporator at 40 ℃. The volume was concentrated down to 1 mL using nitrogen gas evaporation. For HRGC-Ion-Trap-Mass analyses, a coupling system was used by consisting of Trace GC 2000 (Thermoquest, Austin, TX) linked to Polaris Q (Thermoquest, San Jose, CA) with using a 60-m DB-5 column. The initial temperature, 60 ℃ was maintained for 2 min, and then the temperature was increase to 290 ℃ by 10 min and was held at 290 ℃ for 10 min.

Results and Discussion

Characteristics of steeler's dust.

The major components of steeler's dust are metal Fe, FeO, Fe_2O_3, CaO, and SiO_2 (Table 1). At present, POSCO produces nearly 1.2 million tons of steeler's dust every year. About 91% of this steeler's dust is reused as road-fill material and in steel-making process. Figure 1 shows an SEM image of a steeler's dust particle.

The physical characteristics of steeler's dust are listed in Table 2. About 55.85% of steeler's dust is composed of metallic Fe; thus, the reuse of steeler's dust instead of using commercial Fe^0 is an important subject for research. Moreover, FeO and Fe_2O_3 can be ionized in an acidic solution to give ferrous ion and ferric ion. The ferrous ion produced from FeO reacts with hydrogen peroxide to form Fenton's reagent[9].

Table 1 Components analysis of steeler's waste byproducts

Components	M-Fe	FeO	Fe_2O_3	CaO	SiO_2	Al_2O_3	MgO
Composition (%)	55.85	15.28	13.28	9.06	1.23	0.28	1.58

Table 2 Physical characteristics of steeler's waste byproducts

Particle size (㎛)	Specific surface area (m^2/mL)	Standard deviation (㎛)	Coefficient of variation (%)
9.228	0.115	6.42	69.6

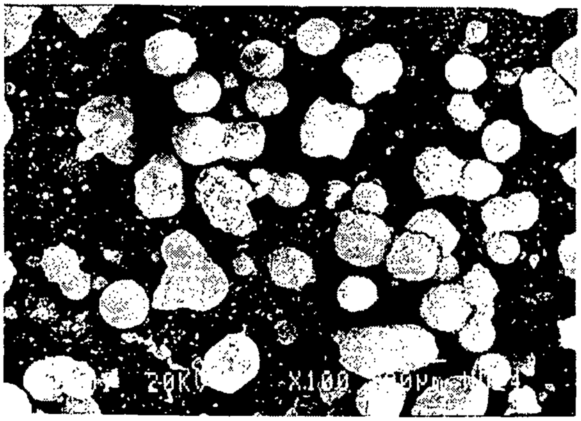

Figure 1. An SEM image of a steeler's dust

Effects of steeler's dust dosage and hydrogen peroxide concentration on the degradation of 1,2,3,4-TCDD.

In this experiment, two different concentrations of hydrogen peroxide (0.25%, 0.5%) were added into the reactor. The experimental results are shown in Figure 2. After 180 min reaction time, addition of 0.25% hydrogen peroxide concentration led to a higher degradation rate of 1,2,3,4-TCDD than the 0.5% concentration.

The effect of steeler's dust dosage on the degradation of 1,2,3,4-TCDD was studied using 5 g/L and 10 g/L solutions, with 0.5% hydrogen peroxide concentration. After 120 min, the degradation rate of 1,2,3,4-TCDD in the 10 g/L dust dosage was 1.8 times higher than that in the 5 g/L dust dosage.

Because steeler's dust is waste material, it is recommended to use high dust dosages. However, the use of too high a dosage cause an increase in sludge byproducts. Therefore, the optimum dosage of steeler's dust and hydrogen peroxide should be determined by experiments.

These experimental results demonstrate that the use of steeler's dust with hydrogen peroxide can be a useful remediation method for treating dioxin-contaminated water.

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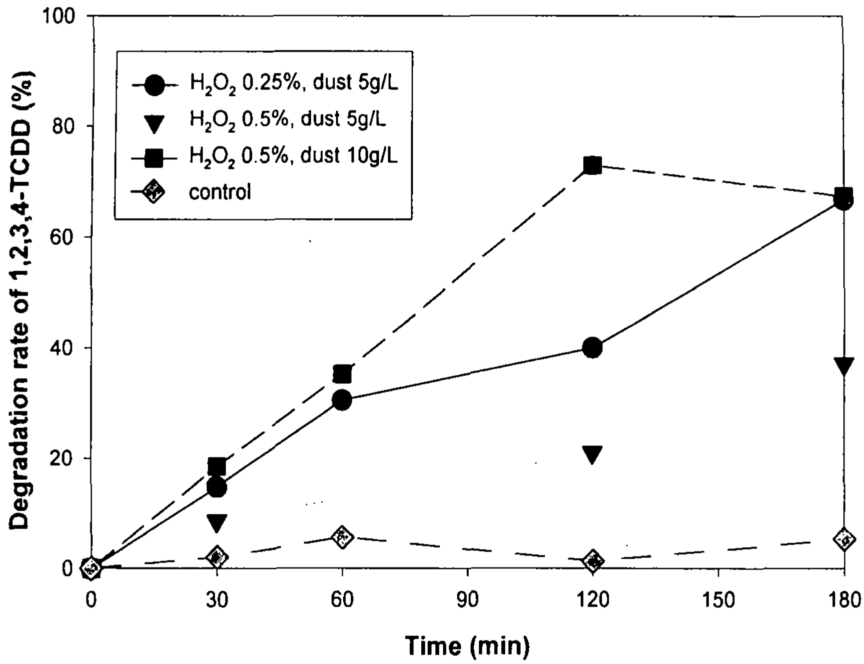

Figure 2. Degradation of 1,2,3,4-TCDD by Fenton-like oxidation
(pH 3, initial 1,2,3,4-TCDD (1 ㎍/mL), 25 ℃, 200 rpm)