Effect of Scavengers on Oxalic Acid Degradation Using Ionizing Radiation

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1. Introduction

Organic acids such as oxalic acid, citric acid, and formic acid are commonly used as cleaning agents to remove metal scales [1].

Various studies are being conducted regarding the removal of organic acids used in advanced oxidation processes (AOPs) [2].

Highly reactive species such as •OH, •H, and e_{aq}^- can be generated to remove organic pollutants by water radiolysis using gamma radiation [3].

The objectives of this study were to demonstrate the radiolytic degradation of oxalic acid and to demonstrate the effect of radical scavengers on oxalic acid degradation using gamma radiation.

2. Materials and Methods

2.1 Materials and Sample Preparation

Oxalic acid, tert-butanol (BuOH), and 2-propanol (PrOH) were purchased from Sigma-Aldrich. All solutions were prepared with distilled water. The initial concentration of the oxalic acid was 20 mM. Radical scavengers (BuOH and PrOH) were added to the oxalic acid solution before irradiation.

2.2 Irradiation Sources

Gamma radiation was achieved using a high-level ^{60}CO source (Nordion Inc., Canada) at Korea Atomic Energy Research Institute (KAERI), Jeongeup, Rep. of Korea. Samples were irradiated at absorbed doses of 5 kGy to 50 kGy.

2.3 Analysis Methods

Oxalic acid was determined using high-performance liquid chromatography (HPLC), with a UV detector at a wavelength of 220 nm. Separation of oxalic acid was achieved using a Synergi 4 um Hydro-RP 80 Å (250 x 4.6 mm). The mobile phase comprised 20 mM potassium phosphate at a flow rate of 0.7 ml/min.

3. Results and Discussion

3.1 Radiolytic Degradation of Oxalic Acid

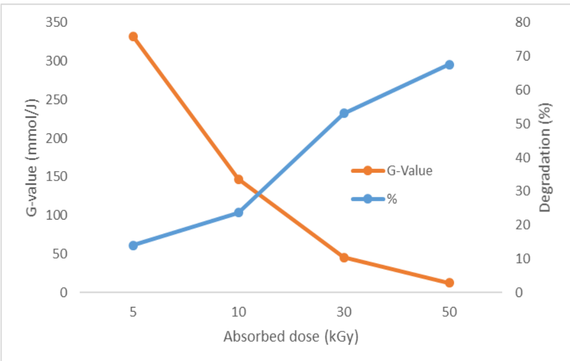

Fig. 1. The relationship between degradation efficiency (%) and G-value of oxalic acid using gamma radiation ([oxalic acid]$_0$ = 20 mM, pH = 2.5).

Fig. 1 shows a comparison between the degradation efficiency and the G-value of oxalic acid using gamma radiation. The degradation efficiency of oxalic acid was 14, 24, 53, and 68 % for an absorbed dose of 5, 10, 30, and 50 kGy, respectively. The degradation efficiency of oxalic acid increased with an increase in the absorbed dose, whereas the G-value of oxalic acid decreased with an increase in the absorbed dose. In other words, the concentration of reactive radical species was decreased with increasing radical–radical recombination reactions.

3.2 Effect of Scavengers on Oxalic Acid Degradation

Fig. 2 shows the degradation of oxalic acid in the presence of scavengers using gamma radiation. Effective radicals were investigated for the radiolytic degradation of oxalic acid. The most active species were •OH, •H, and e_{aq}^- for organic compounds degradation.

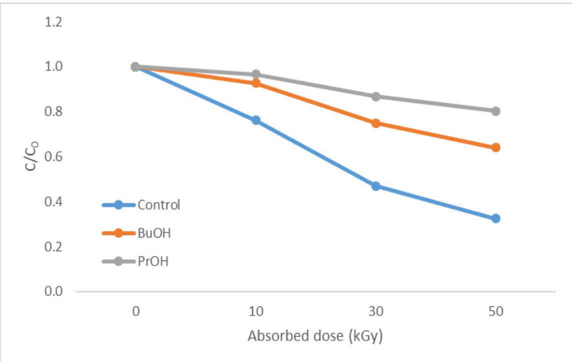

Fig. 2. Effect of scavengers on oxalic acid degradation using gamma radiation ([oxalic acid]$_0$ = [BuOH]$_0$ = [PrOH]$_0$ = 20 mM, pH = 2.5).

BuOH was used as a scavenger of •OH. Therefore, •H and e_{aq}^- play the dominant roles. PrOH can scavenge •OH and •H; thus, e_{aq}^- plays the superior role. As a result, the most active species for oxalic acid degradation is •OH.

4. Conclusion

The G-value of oxalic acid was inversely proportional to the dose constant, whereas the degradation efficiency was directly proportional to the dose constant. The predominant radical species for oxalic acid degradation were investigated. The radical species on oxalic acid degradation were as follows: •OH > •H > e_{aq}^-. Consequently, the most active radical species for oxalic acid degradation was identified as •OH.

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