

# Development of Kr Adsorption Process in Pyroprocessing

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## 1. Introduction

An accumulation of spent fuel has brought a considerable interest due to its energy and environmental issue [1]. Pyroprocessing has been investigated in Korea Atomic Energy Research Institute (KAERI) which reduces the accumulated spent fuel and increases the efficiency of fuel cycle. In head-end process of pyroprocessing,  $UO_2$  pellets are produced from a fuel bundle and various radioactive gases from a spent fuel are released during thermal treatment. Within these gases, Kr is a volatile gas which has a long half-life of 11 years and high radioactivity, and therefore it is imperative to capture Kr [2]. Several methods such as cryogenic distillation, absorption using solvents, and adsorption on solids have been widely applied to Kr capture. Of these approaches, adsorption has many advantages such as its low energy-consumption processes and easy regeneration. In this study, Kr adsorption process was designed and tested using a packed bed column filled with adsorbents. The Kr adsorption performances were determined from breakthrough curves obtained from a gas chromatography, and the effects of adsorption conditions on capacities were investigated.

## 2. Experimental Section

### 2.1 Preparation of Adsorption Test

The adsorbents were pretreated at  $130^\circ\text{C}$  in a vacuum oven for overnight to remove moisture and impurities. The dried adsorbents were packed in a column of a diameter of 30 mm with flowing inert gas to prevent adsorbing water from atmosphere. The flow was  $126\text{ cm}^3\text{ min}^{-1}$  and the pressure was 1 atm.

### 2.2 Gas Analysis

The gas chromatography (GC, DS Science, Republic of Korea) equipped with a pulsed discharge detector (PDD) was used to measure a gas concentration which

passed through the adsorption column. A 30 m of GC column (ValcoPLOT Molesieve 5A) was installed. He gas was used as a carrier gas in GC, and Kr was calibrated using standard gases. The temperature of GC was maintained at  $60^\circ\text{C}$ .

### 2.3 Breakthrough Curve

An adsorption capacity was calculated using a breakthrough time as follows:

$$q = \frac{F}{M} \int_0^t (C_0 - C) dt \quad (1)$$

where  $q$  represent adsorption capacity ( $\text{mmol kg}^{-1}$ ),  $F$  is a flow rate ( $\text{cm}^3\text{ min}^{-1}$ ),  $M$  is a mass of adsorbent (g),  $t$  is a adsorption time (min).  $C_0$  and  $C$  are initial and measured concentration, respectively.

Breakthrough capacity ( $q_b$ ) and equilibrium capacity ( $q_e$ ) were calculated using a breakthrough time ( $t_b$ ) and an equilibrium time ( $t_e$ ), respectively. The breakthrough time is measured when Kr is detected at first time in GC, while equilibrium time is when the Kr concentration reaches to the initial feed gas concentration.

## 3. Adsorption Test

### 3.1 Adsorption Conditions

The commercial adsorbents, activated carbon and zeolite, and a novel adsorbent, metal organic framework (MOF), were selected as adsorbents.

In addition, Kr adsorption was tested with controlling parameters such as Kr concentration and adsorption temperature. From the results, it was found that the adsorption capacities were highly influenced by the Kr concentration and adsorption temperature. The both breakthrough and equilibrium capacity increase as increasing Kr concentration (Fig. 1), however, they decrease with increasing adsorption temperature.

Dynamic results were obtained through composition of gas using GC, and the adsorption performances such as working capacities, equilibrium capacity, and kinetic. Furthermore, the effects of adsorption condition on the adsorption capacities were investigated. These parameter effects will be further applied in optimizing adsorption process.

### 3.2 Adsorption performances

On the other hand, the feed gas in Pyroprocessing contains Hydrogen for reduction, and therefore Kr adsorption test was carried out in 3.2% H<sub>2</sub>-balanced with Ar. It was confirmed that similar result was obtained in the presence of hydrogen which indicates a feasible adsorption process in Pyroprocessing (Fig. 2).

## 4. Conclusion

Adsorption process was designed for Kr capture using packed bed column with adsorbents. Kr adsorption performance was investigated by varying adsorbents and process parameters. It was found that Kr adsorption was highly influenced by Kr concentration and adsorption temperature.

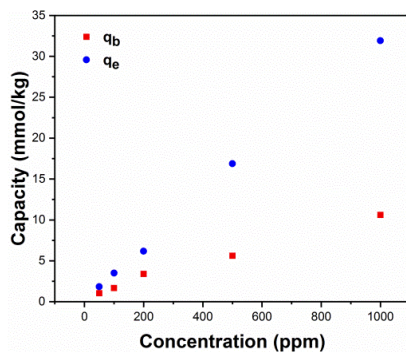


Fig. 1. Adsorption capacities at various Kr concentrations.

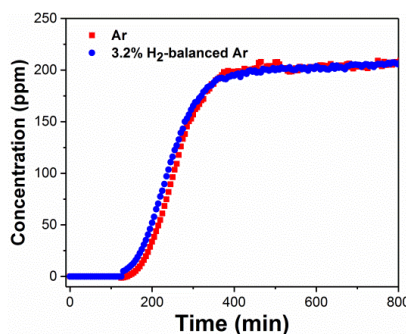


Fig. 2. Breakthrough curves measured at argon and reducing condition.

## REFERENCES

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