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The Attrition Characteristics of Amine-grafted Solid Sorbents for CO_2 Capture in an ASTM Fluidized Bed

Aziz Abidov[1], Vinodh Rajangam[1], Hanseok Oh[1], Mincheol Shin[1],
Wang Seok Cha[2], Hyun Tae Jang[1],

[1] Department of Chemical Engineering, Hanseo University,
Seosan 360-706, South Korea,
[2] School of Civil and Environmental Engineering, Kunsan National University,
Kunsan 573-701, South korea
{Hyun Tae Jang htjang@hanseo.co.kr

Abstract. Amine-grafted silica (AGS) sorbent attrition characteristics for CO_2 capture were investigated in a fluidized bed system (35 mm I.D., 170 mm height) with air-jet equipment based on the ASTM D5757 standards. Difference in particle size distribution, cumulative attrition loss and rates were examined in both wet and dry conditions. The attrition loss increased by time, however this increment was lower in wet condition. The results indicate that amine sorbent particles generate fewer fines than expected. These AGS sorbent particles are suitable for fluidized bed operations.

Keywords: Attrition, amine-grafted silica, fluidized beds, adsorption, APTS

1. Introduction

At present scenario, the global warming and inadequate environment are the high challenges for the researchers to save the people and the environment. Anthropogenic gases are the main culprit for these adverse effects into the earth, especially CO_2 gas playing the vital role in that. Many approaches have been made by the researchers to solve this issues which includes solid chemical and physical adsorbents, hyper cross-linked polymers, amine grafted silica's (AGS), metal organic frameworks, covalently organic functionalized polymer networks has been widely investigated and was found as more feasible, less problematic and economically possible technology for CO_2 capture [1-14]. Among those adsorbent materials, AGS sorbents are promising alternative to CO_2 capture [15]. These technologies will be implemented for fluidized bed applications in power plants. Fluidized beds are best in use for many industrial applications [16]. However, in fluidized bed systems, particulate sorbents face with a significant issues, like particle attrition, mechanical breakage, creation of fines resulting in sorbent loss and decreased performance [17]. There are two kinds of attrition modes: the primary fragmentation where particle fracturing into two or more parts of similar size and occurs directly after introducing particles into the bed and

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second is attrition by abrasion, abrasive creation of fines with smoother surface which rapidly elutriate [18].

Past two decades tremendous recent developments in fluidized bed combustion technology have stimulated research in areas of fluidization which had previously received a great attention. The subject of solid sorbents attrition in fluidized beds has already been treated in relation to, catalytic cracking [l9-21]. However, it is now a topic which is maximum increasing interest owing to the important effect it has on various kinds of combustion technology in fluidized beds.

The production of fines from solids in the bed will lead to a loss both of combustible material from char attrition [22, 23] and of the limestone fed for SO_2 capture, causing a decrease in combustion efficiency and sulfur retention. Heat transmission in the bed will also be affected due to variation in particle size. The design of systems for collecting particles as they leave the reactor will be determined by this phenomenon. Furthermore, the production of very fine particles may have an adverse effect on devices situated at the outlet of the reactor, as in the case of gas turbines in pressurized fluidized beds.

In this present work, we synthesized amine grafted silica by a simple and cheap synthetic route. The brief preparation method involves as follows. First, n-butanol, tetraethyl orthosilicate, aminoprpyl triethoxy silane and water put together in a 5 mL polyethylene filler. Then the mixture placed in 10 minutes for ageing and extruded. The obtained sorbents, attrition behavior was analyzed in the in-house fluidized bed reactor with different particle sizes.

2. Synthesis of porous amino alkyl siloxane matrix

In our method, we have been fabricated a solid alkyl amino group matrix composed of amine, silicate, n-butanol and water. Unlike the amine-grafted or silica-coated sorbents, this sorbent have predominant silicon sites carrying the alkyl amino groups are the matrix builders. Hence, this simple and new sorbent does not undergo leaching. Because of its high density of voids, its CO_2 adsorption capacity is high. Based on these merits, we unveil that it is the ultimate CO_2 sorbent for low temperatures. These reagents and the methods are cheap and simple respectively. The product possesses moderate thermal stability. In addition, it shows high CO_2 sorption capacity.

2.1. Experimental

In this present work, Attrition experiments carried out in an ASTM D5757-95 standard air-jet apparatus [14]. Equipment with total height of 1700 mm, made and consists of stainless steel (SUS 304) components: a horizontal distributor, attrition tube, settling chamber, fine collector with ceramic filter and humidifier. A horizontal air distributor was perforated plate with three-triangularly placed holes with 0.382 mm size. Attrition tube was designed with 35 mm ID and 700 mm height.

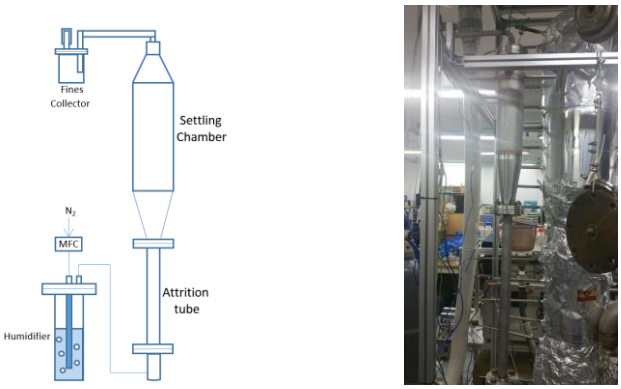

Fig. 1. Photographic and schematic diagram of D5757-95 attrition tester

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