

Preparation of bagasse ash/CaO/ammonium acetate sorbent and modelling their desulphurization reaction

Gadinkosi Dube · Peter Osifo · Hilary Rutto

Received: 25 June 2013 / Accepted: 18 October 2013
© Springer-Verlag Berlin Heidelberg 2013

Abstract The influence of siliceous and hydration agents additives on the preparation of calcium-based sorbents for dry flue-gas desulphurization at low temperature was studied. The key reaction variables investigated are: quantity of bagasse ash, hydration temperature, quantity of ammonium acetate and hydration time. Their effect on the surface area of the sorbent was determined and a central composite design was used as a statistical tool. A polynomial model was established to correlate the sorbent preparation parameters to the sorbent surface area. The desulphurization experiments performed with the thermogravimetric analyser indicate higher SO₂ removal when bagasse ash and ammonium acetate are used. The kinetics of desulphurization reaction was fitted using the unreacted shrinking core model and the results show that the rate-limiting step was diffusion over the product layer.

Keywords Desulphurization · TGA · Hydrating agents · Bagasse ash

Abbreviations

- C_A Bulk concentration of the fluid (mol/cm³)
 D_e Effective diffusion coefficient (cm²/min)
 k_d Apparent rate constant for diffusion through the product layer (min⁻¹)
 k_g Mass-transfer coefficient for the fluid film (cm/min)
 k_r Apparent rate constant for the surface chemical reaction (min⁻¹)
 k_s Rate constant of surface reaction (cm/min)

- R_0 Average radius of solid particle (cm)
 t Reaction time (min)
 X Converted fraction
 ρ_B Molar density of solid reactant (mol/cm³)

Introduction

Pollution is caused primarily by the combustion of fossil fuels; oil and coal are materials which are known to contain great quantities of sulphur. During the burning process, sulphur dioxide is produced from the reaction between sulphur in the presence of oxygen. Acid rain is formed as sulphur dioxide is consequently transformed into sulphurous acid. A legislation to curb the emission of sulphur dioxide was placed in the beginning of 1990 in South Africa (Randall and Matibe 2003).

There are a number of ways of getting rid of sulphur dioxide from the flue gas in industrial processes. The flue-gas desulphurization process methods that are used comprises the wet, semidry and dry. Dry FGD is uncommon compared to wet FGD processes, however, it is more an attractive alternative in small coal-fired power plants (Miszczyk and Darowicki 2002; Gutierrez and Ollero 2008). The advantages of dry FGD process include the low usage of water, less capital intensive and better waste management compared to wet FGD process. However, the sulphur dioxide removal efficiency is lower than the wet FGD process and therefore there is a need to improve the sorbents properties so as to enhance sulphur dioxide capture.

Several siliceous materials have been used with limestone in previous studies. The influence of CaSO₄ and fly

G. Dube · P. Osifo · H. Rutto (✉)
Department of Chemical Engineering, Vaal University of
Technology, Vanderbijlpark Campus, Private Bag X021,
Vanderbijlpark 1900, South Africa
e-mail: hilaryr@vut.ac.za