



## Effects of silica sources on the morphology and acid properties of SAPO-34 molecular sieves

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### ABSTRACT

Silicon-substituted aluminophosphates SAPO-34 molecular sieve has been synthesized under hydrothermal condition by using triethylamine, tetraethylammonium hydroxide, and morpholine as organic structure-directing agents, with different silica sources, such as TEOS and colloidal silica. The extent and effects of silicon substitution on these materials have been investigated by X-ray diffraction, field emission scanning electron microscopy and energy-dispersive X-ray analysis. Their acidity has been measured quantitatively by temperature-programmed desorption of ammonia. Using TEOS as silica source may result in smaller particles, but a lower level of silicon substitution for aluminium and phosphorus compared to colloidal silica.

### Introduction

Aluminophosphate ( $\text{AlPO}_4$ ) molecular sieves were first synthesized in 1982 by Wilson et al [1]. The structure of these materials is similar to that of zeolites, whereas the primary building units in these materials are formed by  $[\text{Al-O-P}]$  linkages instead of  $[\text{Si-O-Al}]$  or  $[\text{Si-O-Si}]$  in zeolite [2]. These materials have no ion-exchange and catalytic capabilities due to its neutral  $\text{AlPO}_4$  network [3, 4]. However, the  $\text{AlPO}_4$  frame is more flexible than that of the zeolites and this makes it possible to replace different atoms at the Al or the P sites [5]. Substitution of silicon into the neutral framework of aluminophosphate, therefore, will lead to a charge imbalance and form a new class called silicoaluminophosphates (SAPO). The protons left after the decomposition of the organic structure directing agents in the calcination neutralize the negatively charged centres and form hydroxyl groups as Bronsted acidic sites [6].

Silicoaluminophosphates have been proven to be an important class of acidic catalysts. Among SAPO family, SAPO-34 catalyst has been investigating widely due to its exceptional selectivity and catalytic for several applications including methanol to olefins conversion,  $\text{NO}_x$  catalytic treatment, etc. [7–9]. SAPO-34 has chabazite structure, small pore openings (about 3.8 Å), channel dimensions 0.43 nm x 0.43 nm, formed by 8-membered oxygen ring [5]. In addition, SAPO-34 was reported to be able to accommodate a large amount of silicon [10]. which is the most important property of such material. Several studies [3, 10-12] proposed two different substitution mechanisms illustrating how Si atoms incorporate into the  $\text{AlPO}_4$  structure. So far only negatively charged frameworks could be synthesized, which means that silicon does not replace isolated aluminium. The first mechanism, denoted as SM1, is that the Si substitute for phosphorus, which causes an increase in negative charges and forms Bronsted acid sites. In the second mechanism, called by SM2, the neighbouring aluminium and phosphorus