

Utilizing Colloidal Silica and Aluminum Doped Colloidal Silica as a Binder in FCC Catalysts: Effects on Porosity, Acidity and Microactivity

Brian T. Holland¹, Velu Subramani² and Santosh K. Gangwal¹
¹Nalco, 1601 W. Diehl Rd., Naperville, IL 60563 USA
²Center for Energy Technology, RTI International, 3040 Cornwallis Rd,
 Research Triangle Park, NC 27709 USA
 *btholland@nalco.com

Introduction

The modern FCC catalyst contains a zeolite and a matrix typically consisting of Kaolin clay and a binder. Although zeolites revolutionized the FCC industry in the 1960's and new zeolites are constantly being developed in both academia and corporate R&D, the FCC matrix binder materials have remained the standard amorphous silica's and alumina's, e.g., sodium silicate, colloidal silica, aluminum chlorohydrate, boehmite, sodium aluminate, etc. One major process step involved with using sodium silicate as the source of silica is that it needs to be washed or ion-exchanged to remove sodium, which if not removed, is detrimental to the development of acid sites in FCC catalysts. The matrix typically provides the physical characteristics of the catalysts, for instance, mesoporosity and macroporosity, attrition resistance, and stability towards heat and steam.[1] In addition to physical characteristics, the matrix can also provide catalytic properties such as acidity for cracking larger oil fractions (bottoms). These larger oil fractions are too large to be cracked efficiently by the zeolite present in the FCC catalyst and, as a result, the larger pores provided by the matrix and the increased acidity should increase bottoms cracking activity.

Of late, Nalco has developed an aluminum doped colloidal silica (colloidal aluminosilicate) material that exhibits some very unique properties,[2] the most important of which is good acidity. The synthesis involves the controlled addition of an aluminum/silicic acid solution to a catalyst, such as, NaOH, KOH or NH₄OH. The intimate mixture of aluminum and silicic acid provides a very homogeneous aluminosilicate particle. A significant advantage of using either colloidal silica or colloidal aluminosilicate particles is that if it is grown with the right catalyst, e.g. NH₄OH, there is no need for further washing or ion exchange. We describe the use of Nalco colloidal silica and the new colloidal aluminosilicate particles as binders in FCC catalysts and their effect on the pore structure, acidity and microactivity.

Materials and Methods

Colloidal aluminosilicate synthesis is described in reference 2. Catalysts containing 35 wt % USY zeolite (with an average particle size of ~2.8 μm), 40-45 wt% kaolin clay (86% <1 μm in size) and 20-25 wt% SiO₂ (Nalco 1130C and 2 wt% Al₂O₃ doped silica both stabilized with NH₄OH) were prepared following a recipe adapted from a patent assigned to Grace (US Patent 4,332,699). For comparison with the FCC catalysts made with colloidal silica and 2 wt% Al₂O₃ doped colloidal silica, a commercial FCC catalyst was tested along side the synthesized catalysts. Characterization included attrition resistance, nitrogen adsorption,

mercury porosimetry, ²⁷Al and ²⁹Si MAS NMR, NH₃-TPD, SEM, TEM and microactivity testing.

Results and Discussion

The use of colloidal silica and 2wt% Al₂O₃ doped colloidal silica as a binder in FCC catalysts has been shown to be quite effective in terms of attrition resistance and porosity. Although, the attrition resistance of the commercial catalyst is better at this time, work is being continued by the Research Triangle Institute (RTI) to obtain comparable attrition resistance with our commercial colloidal silica particles in a FCC catalyst. Also, the porosity generated by the colloidal silica binders is of extreme interest due to the need of the reactants to pass through the colloidal binder system before reaching the active component (zeolite). In addition, the pore size distribution due to the colloidal binder appears to be quite narrow compared to the commercial FCC catalyst, which may be important in preventing areas of increased coking due to plugging of smaller pores.

The addition of the aluminum to the colloidal silica also appears to be a more effective method of including acidity than through separate sources of alumina or even conventional precipitated silica-alumina's as described in literature elsewhere.[3] The gain in acidity with the aluminum doped colloidal silica appears to have a direct effect on microactivity as shown be the selectivity for gasoline, Table 1.

Table 1. Microactivity testing of steamed FCC catalysts

Catalyst Yield (wt%)	FCC with Colloidal Silica	FCC with 2wt% Al ₂ O ₃ Doped Colloidal Silica	Commercial FCC
Dry Gas	1.42	1.34	1.81
C ₃	0.76	0.74	1.06
nC ₄	0.67	0.69	0.95
iC ₄	3.80	3.92	4.71
iC ₄ =	0.90	0.64	0.55
C ₃ =	3.15	2.99	3.19
nC ₄ =	2.84	2.59	2.61
Total LPG	12.11	11.57	13.08
Gasoline	49.66	53.28	53.27
LCO	20.72	19.84	19.45
HCO	13.50	11.00	8.25
Coke	2.59	2.98	4.15
Conversion	65.78	69.17	72.30

References

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3. Scherzer, J., *Catal. Rev.-Sci. Eng.* 31, (3), 215, (1989).