Novel Platinum-Based Nanocatalysts for Naphtha Reforming

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Introduction

Naphtha reforming is used in oil refineries worldwide to produce high-octane reformate product suitable for gasoline blending, and aromatics for petrochemical applications. It is also a net hydrogen-producing process, which makes it particularly valuable because hydrogen is used elsewhere in the refinery, especially for upgrading other hydrocarbon streams. Reforming comprises a number of simultaneous and consecutive reactions, including dehydrogenation, isomerization, dehydrocyclization and hydrocracking, taking place at temperatures around 900 °F and between 50 and 350 psig. Commercial catalysts are bifunctional, generally platinum-based, supported on alumina and also containing chlorine, to enhance acidity, and other metal promoters. While the current process was commercially introduced decades ago, continuous advances in catalyst and process design have made the technology more efficient. Because reforming is applied at very large scale, even small improvements translate into vast economic gains.

Results and Discussion

Headwaters' proprietary approach for catalyst nanoparticle formation has been successfully applied to platinum-based bimetallic catalysts for naphtha reforming. The use of a suitable templating agent results in a catalyst with improved nanoparticle dispersion, composition and surface geometry. This, in turn, favors desirable reforming reactions, such as aromatization and isomerization, while reducing the rate of undesirable ones, such as hydrocracking. Two main formulations have been studied: Pt-Sn for continuous catalyst regeneration (CCR) processes and Pt-Re for semi-regenerative (SR) processes. In both cases, the nanotechnology-derived catalysts were tested side-by-side with commercially available benchmarks, at typical reforming conditions and using refinery-supplied hydrotreated naphtha as feed. Both nanotechnology formulations proved superior to their commercial counterparts using the product octane-barrel number as performance measure. This yield advantage was maintained or even increased during high-severity operation. In addition, varying the nanotemplating agent used during the catalysts' preparation resulted in different yields of aromatics in the reformate product. This provides the potential ability of using different catalyst preparations depending on the intended use of the product, with high-aromatics content preferred for petrochemicals and lower content for fuels. Finally, the catalysts were subjected to accelerated deactivation to study their regenerability using the same procedure as in a typical refinery. After coke-removal, oxychlorination and re-reduction, the nanotechnology-derived catalysts recovered their initial activity and maintained their yield advantage over the regenerated benchmark catalysts.

Significance

Because of the initial success at laboratory scale, the next step in developing these catalysts is their manufacture and trial at commercial scale. Scale-up work is underway at Headwaters' facility in Lawrenceville, NJ for this purpose, with initial success in tests in the 100-lb range. Because of their yield advantage, active negotiations are in progress with prospective customers for commercial scale trials.