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Early Stage Strong Metal Support Interaction (SMSI) Effects In An Experimental Titania-Supported Platinum Catalyst: An Environmental TEM Study

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Environmentally controlled TEM studies have long proven important in developing meaningful nanostructure/property relationship information.[1] This is particularly true for many catalytic systems where small metal particle physical property data (e.g., melting point, freezing point, etc.) varies significantly from the bulk material.[2] Thus, over time, various *in-situ*[1, 3-5] and *ex-situ* [6-8] TEM techniques have been developed to more effectively characterize existing systems. These protocols, however, can also be strategically employed to improve the design of new catalytic systems and to more effectively control nanostructures under reactive conditions.

Standard wisdom often suggests that support materials are inactive at relatively low temperatures and that the primary concern in developing more active/selective materials involves parameters such as metal particle size and composition. However, 500 ^{o}C H_2 chemisorption studies conducted on TiO_2-supported Pt particles revealed that it is a support effect (strong metal support interaction, SMSI) which leads to decreased metal particle H_2 uptake over time and thus decreased catalytic activity. [9-11]

While both detailed conventional TEM (CTEM)[12,13] and careful environmental TEM (ETEM)[14-16] investigations have substantiated the aforementioned chemisorption findings, recent ETEM studies conducted ~200 ^{o}C under ~1 torr H_2 have revealed unanticipated "early stage" SMSI effects in Pt/TiO_2. Pt metal acts as a catalyst and restructures the titania support (Figures 1a-1d). Electronic effects between the Pt and the restructured titania result in metal particle motion as well as metal particle tilting/faceting on the support. These previously undocumented effects result prior to formation of the Ti_4O_7[12-13] SMSI overlayer.

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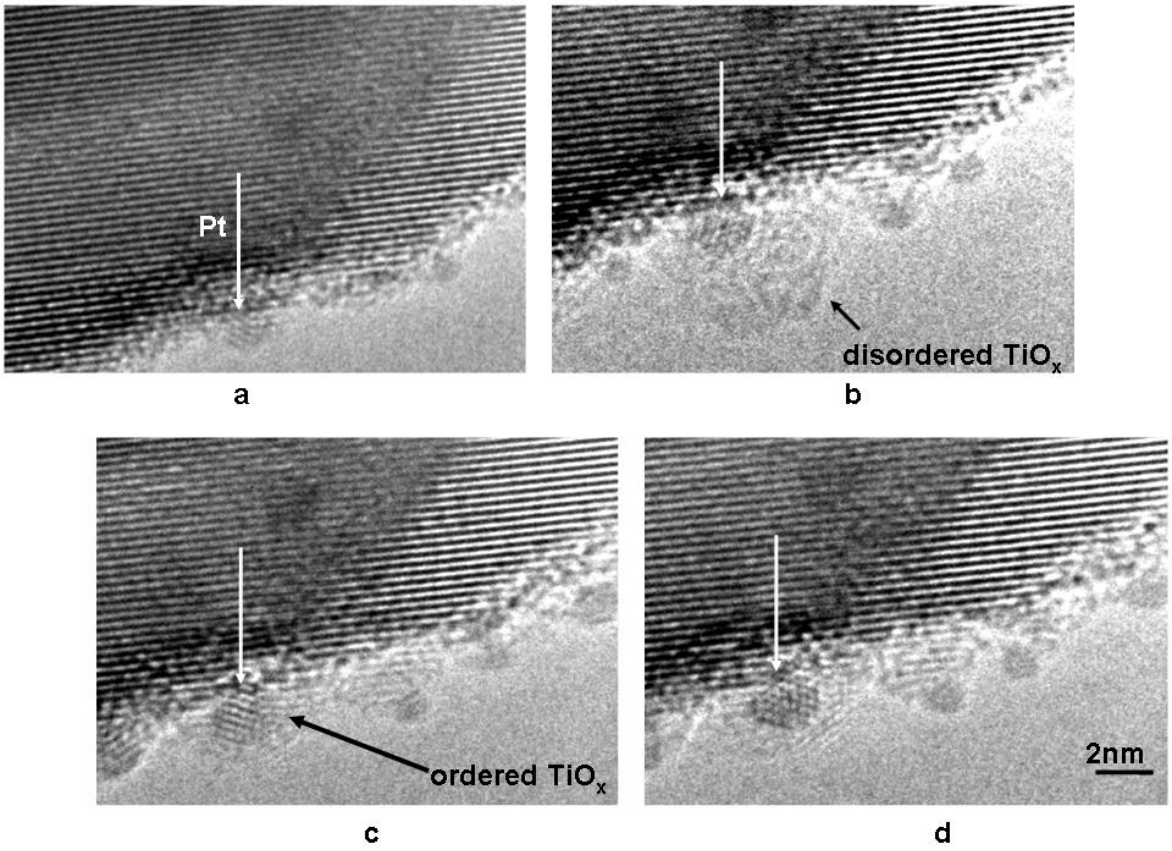

Figure 1: Bright field ETEM images showing Pt/TiO_2 catalyst at ~200 ^oC under ~ 1 torr H_2 after (a) < 1 min, (b) ~1:45 min, (c) ~3:30 min, and (d) ~5 min.

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