

grain boundaries shown in the figures were also present prior to the corrosion testing. Further corrosion testing to 4400 hours also showed no damage to the coating.

**[0134]** Catalyst Preparation for Oxidative Dehydrogenation

**[0135]** Catalysts were prepared by dip coating heat treated aluminized Inconel™ 617 coupons into precursor solution followed by calcination. Precursors included tetraamineplatinum hydroxide (Alfa Aesar), tin 2-ethylhexanoate (Sigma), tetrabutyltin (Sigma). Catalyst metal was applied directly on the dense alumina layer on the coupon substrate. For Pt—Sn catalyst, the order of coating precursors may be important for activity. Preferably, Pt precursor is coated before Sn precursor is applied to obtain a higher catalytic activity (selectivity at given conversion) than Sn coating before Pt coating. Since tin 2-ethylhexanoate is a dense liquid, it was diluted with acetone to ~30 wt % tin 2-ethylhexanoate solution and used for coating. Tetraamineplatinum hydroxide solution was dip coated onto the coupon and calcined at 450° C. for 30 min in air (intermediate calcinations). This step was repeated until a desired weight gain was observed. Tin solution was coated onto the coupon and calcined between 450-550° C. for 30 min to 1 hour in air. This step was repeated until a desired weight gain was observed. After the desired weight was gained, the catalyst coupon was calcined at 850° C. for 4 hours at 5° C./min in air finally.

**[0136]** For LaMnO<sub>3</sub> synthesis, lanthanum nitrate (Aldrich), manganese nitrate (Alfa Aesar) were dissolved in DI water at stoichiometry ratio. After the solution was dip coated on the heat treated aluminized alloy 617 coupons, it was calcined at 450° C. for intermediate calcinations. After attaining the desired loading, it was calcined at 900° C. for 4 hours at 5° C./min. The X-ray diffraction pattern showed that the major phase was LaMnO<sub>3</sub>.

**[0137]** The coupons were inserted into the middle of a microchannel test reactor leaving a rectangular 0.050 cm gap on each of the two major surfaces of the coupon. Prior to insertion of the coupon, the interior of the test reactor was aluminized and heat treated to grow a dense alumina layer. The heat treatment is carried out as follows: Heat up in hydrogen to 1050° C. at 3.5° C./min, isothermally held under Ar at 1050° C. for 1 hour, isothermally held at 1050° C. under 21% O<sub>2</sub>/Ar for 10 hours, and cooled down to room temperature at 3.5° C./min under 21% O<sub>2</sub>/Ar. Reactants flow by the coupon through this gap. The coupons were 0.327 inch wide, 0.115 inch thick, and 1.5 inch long. The coupon temperature was monitored by thermocouples placed 0.25 inches from the top and bottom of the coupon. The test reactor did not have a heat exchanger since it was a single channel device, the area surrounding the test coupon was wrapped in a heating element, sections of the reactor on either side of the heating element were unheated and cooling was rapid.

**[0138]** The reactor was operated at temperatures in the range of 600 to 1050° C. Contact time was varied between 5 and 100 ms. The ethane:oxygen ratio was varied between 2 and 10, and the H<sub>2</sub>:O<sub>2</sub> ratio of the feed kept at 2. Most of the catalyst testing was performed at an ethane:oxygen ratio of 3 and a contact time of 40 ms, and temperature in the range of 800 to 950° C.

**[0139]** Tested samples included a catalyst with a Pt:Sn ratio of 2.4:1 and a catalyst with a Pt:Sn ratio of 1:5.

Reactivity results are shown in **FIG. 5**. SEM of the high loading Sn catalyst showed large spherical Sn particles and some smaller Pt/Sn particles about 2 μm in size. See **FIG. 6**.

**[0140]** Pt/Sn catalyst tested for 185 hours showed no degradation of catalyst performance.

**[0141]** SEM micrographs of both samples showed very different morphology of the catalyst surface. The high Sn loading catalyst showed spherical Sn particles as large as 20 μm in diameter (**FIG. 6**). Platinum or alloy particles were scarcely found but a Pt particle in ~2 μm size was found and an EDS analysis showed that it was alloyed with Sn. The low Sn loading catalyst showed enhanced alloy formation between Pt and Sn and a large range of particle sizes as shown in **FIG. 7** including some very large (greater than 5 μm irregularly shaped flat islands). The surface of the low Sn catalyst was scraped off with a razor blade and the particles analyzed. It contained smaller particles of Pt and Pt—Sn alloy formation between 4-60 nm. A numerical analysis of the smaller particles showed an average size of 11 nm with a standard deviation of 10 nm.

We claim:

1. A microchannel reactor, comprising
  - a reaction microchannel;
  - the reaction microchannel comprising a metal substrate;
  - a dense and substantially defect-free alumina layer disposed on the metal substrate; and
  - catalyst metal particles directly disposed on the alumina layer.
2. The microchannel reactor of claim 1 wherein at least 30% of the mass of the catalyst metal is in the form of particles having a size of 3 μm or more.
3. The microchannel reactor of claim 1 wherein the metal substrate comprises a microchannel wall.
4. The microchannel reactor of claim 3 wherein the metal substrate comprises an aluminide layer on a microchannel wall.
5. The microchannel reactor of claim 4 wherein the catalyst metal particles comprise Pt and Sn in a Pt/Sn atomic ratio in the range of 1 to 4.
6. A method of conducting a chemical reaction, comprising:
  - passing a reactant into the microchannel reactor of claim 1; and
  - converting the reactant to at least one product.
7. A method of conducting a chemical reaction, comprising:
  - passing ethane into the microchannel reactor of claim 5; and
  - converting the ethane to ethylene.
8. A process of making a catalyst in a microchannel reactor, comprising:
  - forming an aluminide layer in an interior microchannel;
  - thermally growing an alumina layer from the aluminide layer; and
  - depositing a catalyst material directly onto the thermally-grown alumina.