

## Lactose oxidation over carbon supported palladium catalysts

Elena V. Murzina<sup>1</sup>, Anton V. Tokarev<sup>1</sup>, Arie J. Plomp<sup>2</sup>, Johannes H. Bitter<sup>2</sup>,  
Irina L. Simakova<sup>3</sup> and **Dmitry Yu. Murzin**<sup>1\*</sup>  
<sup>1</sup>Åbo Akademi University, Turku/Åbo, 20500 (Finland)  
<sup>2</sup>Utrecht University, Utrecht, 3508, (The Netherlands)  
<sup>3</sup>Boskov Institute of Catalysis, Novosibirsk, 630090 (Russia)  
\*dmurzin@abo.fi

### Introduction

Lactose is the most abundant disaccharide available from dairy with the main application in the food industry. Since production of lactose exceeds its consumption it is a relatively cheap basic material for further transformations. The product of lactose oxidation, lactobionic acid (LBA) found important applications, in particular, in food, cosmetics and pharmaceutical industries. LBA has antioxidative properties, thus being primarily utilized in medical applications as an ingredient in preservation solutions for human organs for transplantation. Possibility of selective catalytic lactose oxidation into lactobionic acid (Figure 1 a) is only scarcely studied [1, 2].

Oxidation of sugars is sensitive to the composition of the adsorbed layer, in particular to such facile processes as self poisoning or overoxidation [3]. The measurement of electrochemical catalyst potential during a reaction reflects the situation with oxygen coverage on the catalyst surface. In this work such “*in situ*” measurements were done for a variety of carbon supported palladium catalysts.

### Materials and Methods

A special shaker reactor for *in situ* catalyst potential measurements was constructed (Figure 1b).

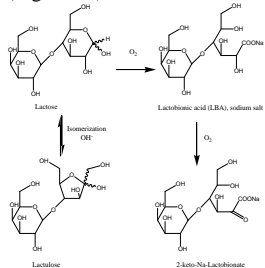


Figure 1 a) Network of lactose oxidation, b) reactor.

The stainless steel reactor walls were utilized as an electrode collector. Potential measurements were performed versus Ag, AgCl/3M KCl electrode. Constant pH of reaction media was maintained by automatic titration device (Metrohm Titrino 751) at pH-stat mode by controlled addition of a NaOH solution. Catalytic experiments were performed in a semi-batch mode. After introduction of the catalyst (0.5 g, particle size < 50 μm) suspended in water, it was pre-reduced by hydrogen (AGA, 99.999 %) at 60 °C for a period of 10 min. Thereafter, the reactor was flushed with nitrogen. The oxygen flow rate through the reactor was 2.5 ml/min. Lactose

(Leprino Foods, Canada) was introduced into the reactor as aqueous solution. In the beginning of each experiment, the overall mass of the reaction mixture was 100 g and D-lactose concentration in the reactor was typically 99.6 mmol/l. The concentration profiles of the reactant and the products were monitored by means of high precision liquid chromatography (HPLC), equipped with a Biorad Aminex HPX-87C carbohydrate column according to the method described in [4]. Several carbon supported palladium catalysts were applied, including commercial ones, supplied by Degussa and Aldrich, self prepared using as supports birch activated carbon and sunit, as well carbon nanofibers with control acidity.

### Results and Discussion

Kinetic data for one of the tested catalysts (4%Pd/sibunit) are presented in Figure 2.

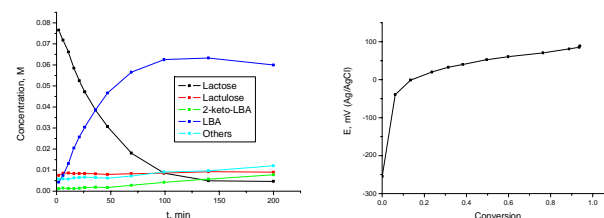


Figure 2. Lactose oxidation over 4%Pd/sibunit at 70°C, pH=8. a) Concentration vs time b) Catalyst potential vs conversion.

In general catalyst potential behavior during lactose oxidation can be characterized by the presence or absence of linear parts, by slopes of these parts, and by the final value of the catalyst potential. Final values of catalyst potential are characteristic for the chosen conditions (T, p (O<sub>2</sub>), pH) and catalytic system (i.e. metal and support nature). As can be seen from Figure 2 as lactose concentration decreases the reaction becomes slower and non-reacted oxygen accumulates on the catalyst surface. Dependences of the electrochemical catalyst potential on time (Fig. 2b) have linear parts with different slopes. The slope characterizes the rate of accumulation of non-reacted oxygen on the surface. Since over-oxidation should be prevented, the surface should not be saturated with oxygen, therefore reaction is unavoidable conducted under conditions of oxygen supply control. For a set of palladium catalysts supported on carbon nanofibers heat treated at different temperatures it was found that the catalytic activity is proportional to the surface acidity. More details on the relationship between the support properties and the catalyst performance will be provided in the presentation.

### References

1. Abbadi, A., Gotlieb, K.F., Meiberg, J.B.M. and van Bekkum, H. *Appl. Catal. A* 156, 105 (1997).
2. Tokarev, A.V., Murzina, E.V., Kuusisto, J., Mikkola, J.-P., Eränen, K. and Murzin, D.Yu. *J. Molec. Catal. A. Chem.*, 255, 199 (2006).
3. Mallat, T. and Baiker, A. *Topics in Catalysis*, 8, 115 (1999).
4. Simms, P.J., Hicks, K.B., Haines, R.M., Hotchkiss, A.T. and Osman, S.F. *J. Chromatogr. A*, 667, 67 (1994).