

candidate catalysts. Other combinatorial or even conventional techniques, which give more detailed or complementary information about the catalytic processes involved, could be then employed to aid catalyst selection. Some of these techniques, such as kinetic studies or mass spectrometric screening, are more time consuming due to the much more detailed information obtained; but as a result of employing the ECIRT screening, there are fewer selected candidate catalysts to examine. ECIRT could therefore be applied to reduce the amount of time and effort involved in new heterogeneous catalyst selection for gas-phase reactions.

References

- 1 S. R. Wilson and A. W. Czarnik, "Combinatorial Chemistry - Synthesis and Application", John Wiley & Sons, New York, 1997
- 2 B. Jandeleit, D. J. Schaefer, T. S. Powers, H. W. Turner and W. H. Weinberg, *Angew. Chem. Int. Ed.*, 1999, **38**, 2495
- 3 P. C. Cong, R. D. Doolen, Q. Fan, D. M. Gianquinta, S. Guan, E. W. McFarland, D. M. Poojary, K. Self, H. W. Turner and W. H. Weinberg, *Angew. Chem. Int. Ed.*, 1999, **38**, 484
- 4 S. M. Senkan, *Nature*, 1998, **394**, (6691), 350

- 5 F. C. Moates, M. Somani, J. Annamalai, J. T. Richardson, D. Luss and R. C. Willson, *Ind. Eng. Chem. Res.*, 1996, **35**, 4801
- 6 A. Holzwarth, H.-W. Schmidt and W. F. Maier, *Angew. Chem. Int. Ed.*, 1998, **37**, 2644
- 7 S. J. Taylor and J. P. Morken, *Science*, 1998, **280**, (5361), 267
- 8 M. T. Reetz, M. H. Becker, K. M. Kühling and A. Holzwarth, *Angew. Chem. Int. Ed.*, 1998, **37**, 2647
- 9 Instruction Manual of the AEGAIS-IR camera by AIM
- 10 W. Gross, Th. Hierl and M. Schulz, SPIE's (Int. Soc. for Optical Engineering) Int. Symp. on Optical Science, Engineering and Instrumentation, San Diego, 1998
- 11 M. Schulz and L. Caldwell, *Infrared Phys. Technol.*, 1995, **36**, 763
- 12 H. Orzesek, R. P. Schultz, U. Dingerdissen and W. F. Maier, *Chem. Eng. Technol.*, 1999, **22**, 691
- 13 C. Lange, Pd.D. thesis, Universität GH Essen, 1998

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Novel Hydrodynamic Ultramicroelectrodes

Ultramicroelectrodes (UMEs) have had great impact on electrochemistry. A novel hydrodynamic UME has now been introduced where mass transfer to the electrode is significantly enhanced by the convective flow of a solution (1, 2). In the microjet electrode (MJE) (1), a jet of solution is fired at $\sim 100 \text{ m s}^{-1}$ from a nozzle (diameter $\sim 25\text{--}100 \mu\text{m}$) onto a disc UME, typically Pt (diameter $25 \mu\text{m}$). The MJE has well defined, variable and high mass transfer rates.

In the radial flow microring electrode (RFMRE) (2), solution flows from a nozzle, placed close to a planar substrate. A Pt ring UME (thickness $\sim 100\text{--}500 \text{ nm}$) is positioned around the capillary edge, followed by an epoxy resin layer, so only a ring of metal at the capillary end is exposed to solution. The Pt is applied as a paint. As fluid leaves the capillary, it is forced into the nozzle/substrate gap ($\sim 5\text{--}40 \mu\text{m}$) and flows radially past the ring electrode. At moderately low volume flow rates, the device has produced the highest steady-state mass transfer rate of any hydrodynamic technique ($\sim 2 \text{ cm s}^{-1}$).

The high mass transport rates of the MJE and RFMRE have resulted in kinetic applications and possible uses in electrochemical flow systems. When coupled with hydrodynamic modulation voltammetry

(HMV) higher detection limits and electrode stability in flow systems can be obtained (1b, 2b).

The MJE-HMV offers the lowest concentration detection limits in a flow system of any hydrodynamically-modulated technique. The mass transport rate is modulated by oscillating the jet to hit and miss the electrode surface. The technique can discriminate against background processes, and IrCl_6^{3-} at $5 \times 10^{-8} \text{ mol dm}^{-3}$ has been detected. The technique is being developed as an electrochemical detector for liquid chromatography.

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References

- 1 (a) J. V. Macpherson, S. Marcar and P. R. Unwin, *Anal. Chem.*, 1994, **66**, 2175; (b) J. V. Macpherson and P. R. Unwin, *ibid.*, 1999, **71**, 4642
- 2 (a) J. V. Macpherson and P. R. Unwin, *Anal. Chem.*, 1998, **70**, 2914; (b) *ibid.*, 1999, **71**, 2939

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