# Reply to N.M. Vegter 'Discussion on the kinetics of the elution of gold from activated carbon'

in the *Journal* of SAIMM, vol. 97. 1997. pp. 197—200.

by M.J. Nicol* and M.D. Adams†

Mr Vegter has analysed, in some depth, the approximations made in the treatment of the kinetic data presented in the original by ourselves (ref.1) and has come to the conclusion that 'under the experimental conditions used by Adams and Nicol (1986) the steady-state assumption was inaccurate'. We are acutely aware of the fact that the experimental method adopted does not permit the attainment of a true steady-state in the elution reactor. However, this does not eliminate the attainment of a pseudo steady-state by a suitable choice of the experimental parameters with the accompanying simplification of the analysis of the data with the aim of drawing the reader's attention to the most important objective of the paper viz. the effect of various operating parameters on the rate of elution of gold.

The following points should be noted in this respect.

- As pointed out on p113 of the paper, the experimental conditions were chosen such that rate of accumulation of gold in the solution of the reactor (*which could be experimentally measured*) was small relative to both the loss by flow from the reactor and to that lost by elution from the carbon in the reactor. This operating condition allowed for the simplification of the analysis of the data as shown in the paper. As pointed out in the paper, this assumption is not valid during the initial stages of the experiment before the pseudo steady-state is achieved and this was allowed for by only analysing the data after this period. Under these conditions, equation [20] of Vegter's comments applies. It should be pointed out that this procedure is well accepted in the kinetic literature as being a desirable method of dealing with such systems. The validity of this approach depends on the accuracy expected in the final analysis. It is likely, and was considered at the time, that other experimental factors such as the ideality of the reactor as approximating a continuous stirred tank reactor would probably produce errors greater than those generated by the assumption of pseudo-steady-state behaviour which could, as mentioned above, be experimentally estimated. These comments apply equally to the other papers cited by Vegter, which employed similar experimental conditions.
- Vegter has, in Figure 1 of his comments, presented data which graphically show the conditions under which the steady-state assumption can be treated as a reasonable approximation, i.e. it compares the kinetic response expected using the integrated form of our equation [2] with that for the approximate form (our equation [3]) for various values of the dimensionless parameters $\gamma$ and $\eta$. It should be pointed out that the latter contains the rate constant (k), the parameter which we seek to obtain. Superposition of our data (shown, for example in Figure 3 of our paper ref. 1)) on his curves shows that it approximates the conditions which apply to $\gamma$=0.1 and $\eta$=1.0, or $\gamma$=1.0 and $\eta$=10.0, or $\gamma$=10.0, and $\eta$>10.0—all of which show small deviations of the approximate from the complete treatment. It is thus not necessary for Vegter to incorrectly assume (as he has done in his Table I) experimental conditions for our experiments by comparison with experiments carried out several years apart on different systems in different laboratories.
- While it is, in theory, possible to analyse each experimental run in terms of the transient behaviour of a CSTR as suggested as being more accurate and preferable by Vegter, we would argue that, provided the conditions are correctly selected, the results are, within the other experimental errors, equivalent. As shown in our paper, variation of the mass of carbon in the reactor and the flow-rate enabled us to obtain a kinetically-derived value for the adsorption equilibrium constant which compared very favourably with that found from equilibrium measurements—further confirmation of the validity of our pseudo-steady-state assumption.

Finally, it is our view that the impact on the critical reader of a linear kinetic plot over two to three orders of magnitude of concentration (such as our Figure 3) is often preferable to the modern trend of analysis which derives parameters of dubious physical significance by curve-fitting of data obtained under conditions inappropriate for the derivation of some of these parameters. We believe this to be the case in point and would therefore argue against the approach suggested by Vegter.

## References

1. Adams, M.D. and Nicol, M.J. The kinetics of the elution of gold from activated carbon. Fivaz, C.E. and King, R.P. (eds.). Gold 100. Proceedings of the International Conference on Gold, South African Institute of Mining and Metallurgy, Johannesburg, vol. 2. 1986. pp. 111—121 ◆

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## OBITUARIES

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| E. Collier | Retired Fellow | 10 June 1949 | 2 September 1997 |
| J.L. Curtis | Retired Fellow | 25 January 1941 | 2 September 1997 |
| D.G. Malan | Honorary Fellow | 1 March 1966 | 11 September 1997 |
| J.A. Northcott | Retired Fellow | 11 September 1953 | 20 June 1997 |
| D. de V. Oxford | Retired Fellow | 1 January 1941 | 4 August 1997 |
| A.N. Shand | Retired Fellow | 14 March 1947 | September 1997 |
| H.V. Solomon | Retired Fellow | 13 April 1962 | 8 February 1997 |
| Dr W.C. Walmsley | Life Fellow | 27 August 1941 | 8 August 1997 |

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