

Discussion on quartic autocatalytic kind of chemical reaction

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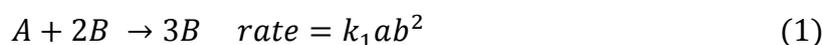
Abstract: The significance of chemical reaction is inevitable and there exist many kinds in real life. Recently, the concept of quartic autocatalytic kind of chemical reaction was appraised (Refs. [10] – [16]). It is worth remarking that the concept had been wrongly used in a recently published paper. To avoid confusion, this unpublished paper is presented for clarification. In the report “entropy optimization and quartic autocatalysis in MHD chemically reactive stagnation point flow of Sisko nanomaterial, International Journal of Heat and Mass Transfer 127, 829 – 837”, the author investigated cubic autocatalytic kind of chemical reaction between non-Newtonian Sisko fluid and two molecules of catalyst situated at the surface. However, in three different places including the title, the author claimed that the reaction is quartic autocatalysis. Also, the chemical reaction scheme $A^* + B^* \rightarrow 3B^*$ is not balanced. The misleading information on this concept is clarified in this report. A recommendation that would help experts in the industry to grasp the significance of quartic autocatalysis is provided.

Keywords: Chemical Reaction, Quartic autocatalysis, Cubic autocatalysis, Sisko Fluid, homogenous-heterogeneous.

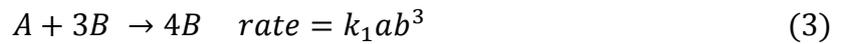
Introduction

An interaction between two or more substances which produces either one or more new substance (i.e. chemical compounds) is known as chemical reaction Kenneth [1] and IUPAC [2]. In some cases, accelerator (i.e. catalyst) and heat are required to speed up the chemical reactions. Homogeneous catalytic reaction presents the case in which the catalyst is in the same state as the reactant(s) while in the heterogeneous catalytic reaction, the reactants and catalyst are in different states. The reaction between two liquids or any two gases is typical examples of the first case while the mixture between liquid and solid catalyst or gas and liquid catalyst are typical examples of the latter case. In any chemical reaction, if the product is a catalyst which even speeds up the chemical reaction, then such chemical reaction is said to have passed through autocatalysis. However, the simplest structural units that retain the properties of homogeneous bulk fluid and catalyst are the yardsticks in determining the kind of autocatalysis Lotka [3], Kim [4], Sapre [5], Hu and Sapre [6].

There are some published articles on the significance of autocatalysis when the molecule of the catalyst is two. The correct model is presented as Eq. (1a) and Eq. (1b) by Chaudhary and Merkin [7], Eq. (1) and Eq. (2) by Animasaun *et al.* [8] and recently as Eq. (1) and Eq. (2) by Ammarah Raees [9] as



where A and B are the dimensional concentrations of the homogeneous bulk fluid and catalyst. k_1 and k_s are the rate constants associated with homogeneous and heterogeneous reactions. The above case of autocatalysis kind of homogenous-heterogeneous chemical reaction is called Cubic autocatalysis. In the year 2016, an insight into the case of three molecules of catalyst and its corresponding effects on the transport phenomenon of 47 nm alumina–water nanofluid on an upper horizontal surface of a paraboloid of revolution was unravelled by Animasaun [10]. In page 2376 of the report, it was written: “*In most cases when the concentration of homogeneous species B is highly substantial, the cubic autocatalator kinetics may not be sufficient; hence isothermal quartic autocatalytic reaction is needed in order to unravel the motion and behaviour of the flow within the boundary layer.*” The correct model for quartic autocatalytic chemical reaction is presented as Eq. (2) and Eq. (3) in Ref. [10] as



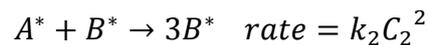
This led to the investigation of the influence of quartic autocatalysis chemical reaction on the flow of (36 nm) alumina-water nanofluid and bioconvection by Makinde and Animasaun [11,12], thermophoresis and Brownian motion of 29 nm CuO in the presence of quartic autocatalysis chemical reaction by Koriko *et al.* [13], the dynamics of micropolar fluid problem over an upper horizontal surface of a paraboloid of revolution in the presence of quartic kind of autocatalytic chemical reaction by Koriko *et al.* [14], motion of 36 nm alumina-water nanofluid when viscosity, thermal conductivity, the volumetric coefficients of thermal expansion, the density of the nanofluid, the heat capacity of the nanofluid, electrical conductivity of the nanofluid, thermal diffusivity of nanofluid, and thermal conductivity of the nanofluid vary with volume fraction by Animasaun and Sandeep [15]. Recently, the same concept of quartic autocatalytic kind of chemical reaction was adopted by Koriko *et al.* [16] to examine the chemical reaction between homogeneous (Eyring-Powell 36 nm alumina-water) bulk fluid and heterogeneous (three molecules of the catalyst at the surface).

Extracted misleading information from Ijaz Khan *et al.* [17]

In page 830, right column, Ijaz Khan *et al.* [17] remarked that “*The model of quartic chemical reaction [16] in boundary layer region with species A and B is presented as [34]:*”



where specie B has larger concentration on surface. The single first-order isothermal reaction on the catalyst is



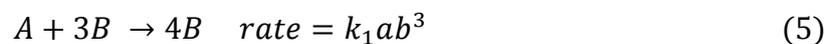
Also, in the same page, it was written: “*Here we aim to investigate the MHD quartic autocatalysis in chemically reactive flow of Sisko nanomaterial over a stretched.*”

Discussion on the misleading information

It is worth remarking that the aim and objectives of Ref. 16 – “G. J. Reddy, B. Kethireddy, M. Kumar, M.M. Hoque, *A molecular dynamics study on transient non-Newtonian MHD Casson fluid flow dispersion over a radiative vertical cylinder with entropy heat generation*, *J. Mol. Liq.* 252 (2018) 245–262” cited by Ijaz Khan *et al.* [17] neither contain concentration equation nor chemical reaction. Also, Ref. 34 – “A. Raees, R.Z. Wang, H. Xu, *A homogeneous-heterogeneous model for mixed convection in gravity-driven film flow of nanofluids*, *Int. Commun. Heat Mass Transfer* 95 (2018) 19 – 24” presents the case of cubic autocatalysis, not quartic autocatalysis as claimed by Ijaz Khan *et al.* [17]. It is worth pointing out that the chemical reaction scheme $A^* + B^* \rightarrow 3B^*$ is not balance. However, these errors contradict the statement by Animasaun [10], Chaudhary and Merkin [18]. The title of the paper – Ref. [17] is “*Entropy optimization and quartic autocatalysis in MHD chemically reactive stagnation point flow of Sisko nanomaterial*”. This implies that the major variables to be considered are “*Entropy optimization*” and “*Quartic autocatalysis*”. Meanwhile, the published article lacks theoretical and empirical reviews of quartic autocatalysis. This might have caused the errors. Lastly, non-dimensionalization, parameterization, the analysis of the study and discussion of results are correct.

Recommendation

The ratio of mass to volume is known as concentration. This property of fluid refers to the amount of a substance or constituents per defined space. One of the established facts in chemistry is that the concentration of fluid substance depends not only on the volume but also on the temperature. In the industry, the mass transfer process is mainly dependent on the species whose concentration varies (Khan *et al.* [19]). Moreover, surface diffusion, Brownian motion, collective diffusion, osmosis, effusion, electron diffusion, facilitated diffusion, gaseous diffusion, Knudsen diffusion, momentum diffusion, photon diffusion, reverse diffusion, and self-diffusion are major types of diffusion which are inevitable. Several experimental investigations on osmosis have shown that the migration of molecules is bound to occur and the main reason is to establish equality of concentrations on both sides of the membrane. Based on these facts, a simple model for homogeneous-heterogeneous reaction in boundary-layer flow in which the reaction between one molecule of homogeneous (bulk fluid) and three molecules of heterogeneous (catalyst at the surface) is of the form



where A and B are the dimensional concentrations of the homogeneous bulk fluid and catalyst. k_1 and k_s are the rate constants associated with homogeneous and heterogeneous reactions. The dimensional governing equation for the concentration of the bulk fluid (a) and that of the concentration of the three molecules of catalyst (ℓ) in a two-dimensional boundary layer flow are

$$u \frac{\partial a}{\partial x} + v \frac{\partial a}{\partial y} = D_A \frac{\partial^2 a}{\partial y^2} - k_1 a \ell^3 \quad (7)$$

$$u \frac{\partial \ell}{\partial x} + v \frac{\partial \ell}{\partial y} = D_B \frac{\partial^2 \ell}{\partial y^2} + k_1 a \ell^3 \quad (8)$$

Subject to

$$D_A \frac{\partial a}{\partial y} = k_s a, \quad D_B \frac{\partial \ell}{\partial y} = -k_s a \quad \text{at } y = 0 \quad (9)$$

$$a \rightarrow a_o, \quad \ell \rightarrow 0 \quad \text{as } y \rightarrow \infty \quad (10)$$

Following Ref. 7 – Ref. 10, the effect of increasing the strength of the concentration of the catalyst on the dynamics of various fluids in the industry is recommended for future investigations. For the appropriate governing equation in which migration of nanoparticles is dependent on thermophoretic force and concentration of the bulk fluid, see Animasaun [10].

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