



# The first experimental confirmation of the fractional kinetics containing the complex-power-law exponents: Dielectric measurements of polymerization reactions

R.R. Nigmatullin<sup>a,\*</sup>, A.A. Arbuzov<sup>a</sup>, F. Salehli<sup>b</sup>, A. Giz<sup>b</sup>, I. Bayrak<sup>b</sup>, H. Catalgil-Giz<sup>b</sup>

<sup>a</sup>Theoretical Physics Department, Kazan State University, Kremlevskaya Street 18, 420008 Kazan, Tatarstan, Russian Federation

<sup>b</sup>Department of Physics, Istanbul Technical University, Faculty of Sciences and Letters, Maslak 80626, Istanbul, Turkey

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## Abstract

For the first time we achieved incontestable evidence that the real process of dielectric relaxation during the polymerization reaction of polyvinylpyrrolidone (PVP) is described in terms of the fractional kinetic equations containing *complex*-power-law exponents. The possibility of the existence of the fractional kinetics containing non-integer complex-power-law exponents follows from the general theory of dielectric relaxation that has been suggested recently by one of the authors (R.R.N). Based on the physical/geometrical meaning of the fractional integral with complex exponents there is a possibility to develop a general theory of dielectric relaxation based on the self-similar (fractal) character of the reduced (averaged) microprocesses that take place in the mesoscale region. This theory contains some essential predictions related to existence of the non-integer power-law kinetics and the results of this paper can be considered as the *first* confirmation of existence of the kinetic phenomena that are described by fractional derivatives with complex-power-law exponents. We want to stress here that with the help of a new complex fitting function for the complex permittivity it becomes possible to describe the whole process for real and imaginary parts *simultaneously* throughout the admissible frequency range (30 Hz–13 MHz). The fitting parameters obtained for the complex permittivity function for three temperatures (70, 90 and 110 °C) confirm in general the picture of reaction that was known qualitatively before. They also reveal some new features, which improve the interpretation of the whole polymerization process. We hope that these first results obtained in the paper will serve as a good stimulus for other researches to find the traces of the existence of new fractional kinetics in other relaxation processes unrelated to the dielectric relaxation. These results should lead to the reconsideration and generalization of irreversibility and kinetic phenomena that can take place for many linear non-equilibrium systems.

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## 1. Introduction

Recently much attention has been paid to existence of kinetic equations containing non-integer operators of differentiation and integration (NIODI) with *real* fractional exponent [1–7]. But papers, related to the *theoretical* consideration of the fractional equations containing NIODI, were realized on an “intuitive” level in the form

of some postulates/suppositions *imposed* on the model considered. At the present time a systematic deduction of kinetic equations containing non-integer integration/differentiation operators from a structure of a disordered medium using the methods of non-equilibrium statistical mechanics is *absent*. So, there is an urgent need to derive the kinetic equations with NIODI from the first principles of the statistical mechanics (and ideally to confirm their existence in nature), based on the consideration of an infinite chain of equations for a set of correlation functions. This problem has been recently solved [8], where

\*Corresponding author. Tel.: +7 84323606123; fax: +7 902122856386.  
E-mail address: [nigmat@knet.ru](mailto:nigmat@knet.ru) (R.R. Nigmatullin).