

# Lignin-Stabilized Doxorubicin Microemulsions: Synthesis, Physical Characterization, and In Vitro Assessments

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## Description of dynamic light scattering (DLS) technique and mechanism of data analysis

DLS is a powerful characterization tool to measure the particle size and diffusion coefficient of nanoparticles in a colloidal suspension. The time-mediated light scattering intensity from the colloidal suspension is a variable quantity dependent on Brownian motion, diameter, and the diffusive behavior of nanoparticles in the solution. These fluctuations can be characterized according to the normalized autocorrelation function,  $g^1(\tau)$ , of the dispersed electric field for a specified time,  $\tau$ , which comprises information about the dynamics and structure Equation (1) [1–4].

$$g^1(q, \tau) = \frac{\langle E(q, t) E^*(q, t + \tau) \rangle}{\langle I(q, t) \rangle} \quad (1)$$

where,  $E^*$  denotes the complex conjugate of  $E$ . The intensity autocorrelation function,  $g^2(q, \tau)$ , is experimentally measured using the relation as follows Equation (2) [2–4]:

$$g^2(q, \tau) = \frac{\langle E(q, t) E^*(q, t) E(q, t + \tau) E^*(q, t + \tau) \rangle}{\langle I^2(q, t) \rangle} \quad (2)$$

The  $g^2(q, \tau)$  is changed to  $g^1(q, \tau)$ , the autocorrelation function of the scattered electric field by the Siegert relationship Equation (3) [2–4].

$$g^2(q, \tau) = |A \exp(-\Gamma \tau)|^2 \quad (3)$$

For a colloidal system having colloidal particles such as micelles and other nanoparticles, a single exponential decay curve represents the function of  $g^1(q, \tau)$  Equation (4) [2–4].

$$g^1(q, \tau) = A \exp(-\Gamma \tau) \quad (4)$$

It is important to note that there is a digital correlator within the DLS tool that assesses the extent of similarity between two signals over a period. If the signal's intensity of a specific part of the speckle pattern at a given point is comparable to the signal's strength a very short time later, the resulting two signals are very similar, and they

powerfully correlate with each other. On the other hand, the correlation between two signals decreases with time due to a decrease in the similarity of two signals by Brownian motion.

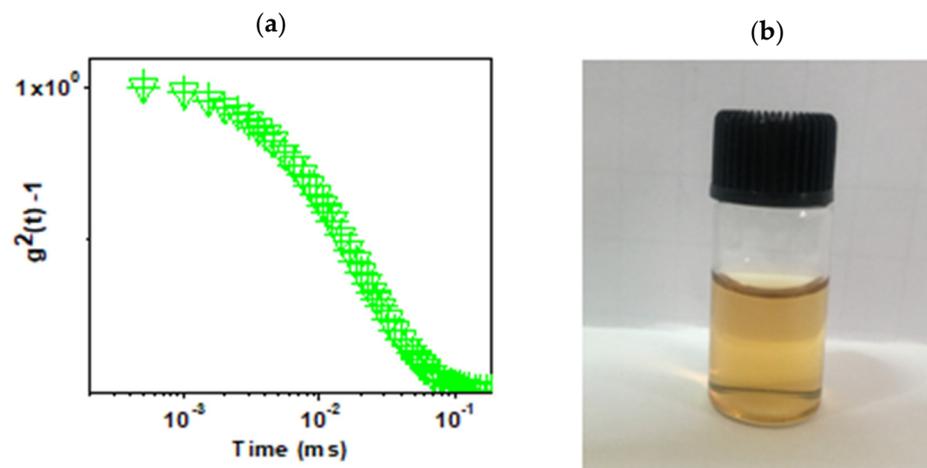
The decay rate,  $\Gamma$ , is transferred to the diffusion coefficient using the following equation Equation (5) [2–4]:

$$D = \Gamma/q^2 \quad (5)$$

where  $q$  illustrates the scattering vector [2–4]. The diffusion coefficient of nanoparticles or micelles can be characterized as  $R_h$  according to the Stokes–Einstein equation Equation (6) [2–4]:

$$R_h = \frac{k_B T}{6\eta\pi D} \quad (6)$$

An increase in particle sizes results in a slow exponential relax with a small relax constant value, as the fluctuations in light intensity change more slowly. In contrast, a stretched relaxing exponential function is obtained for smaller particles with a larger relaxing constant value. Thus, the inverse correlation time is inversely associated with the NPs' diameter/size [2–4].



**Figure S1.** Dynamic light scattering autocorrelation function of microemulsions (a) and visual stability of microemulsion after 3 months (b).

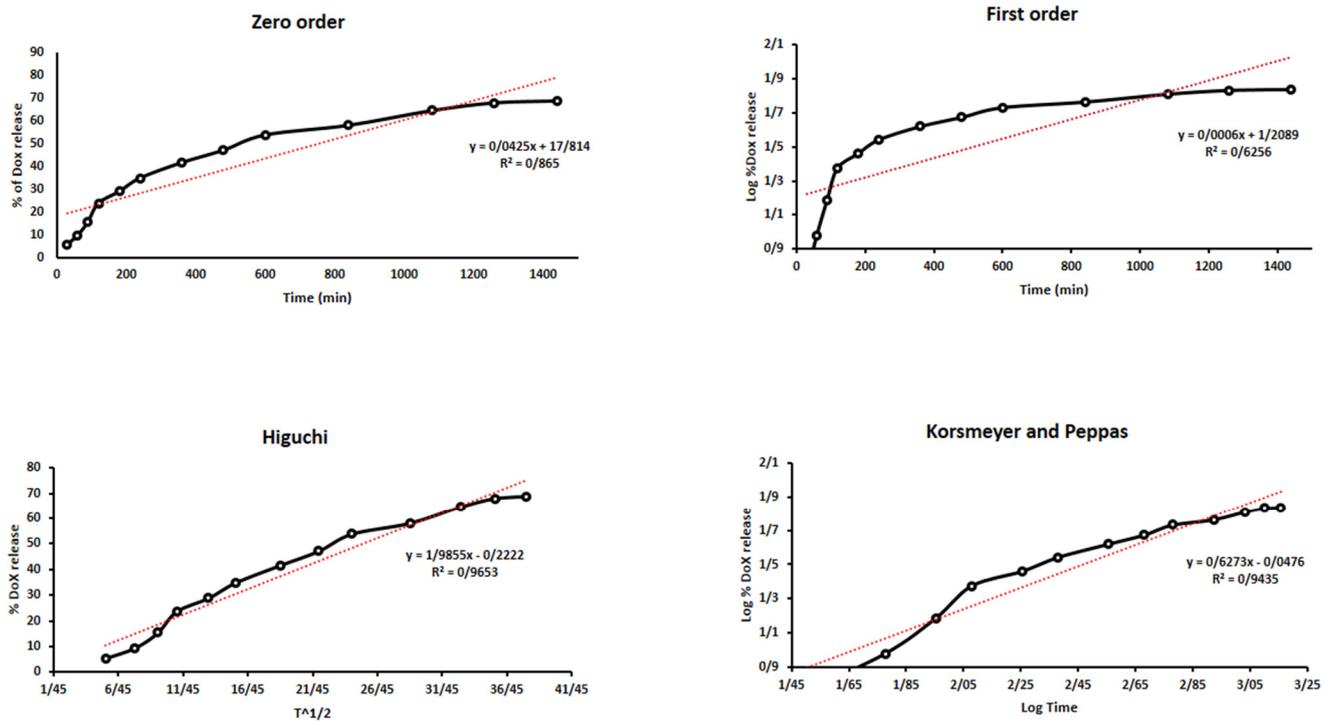


Figure S2. Profiles of different kinetic models for release of DOX from LGN/DOX microemulsions.

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