Photo-polymerization: Kinetics, Efficacy and Clinical Applications

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In this Chapter, we will review the fundamentals, kinetics, and strategies for optimal efficacy in various clinical applications including cancer therapy, corneal crosslinking and functional biomaterials. Matching the light absorption peaks at wavelengths of UVA (365 nm), visible (530-660 nm), and near-IR (780-810 nm), various photosensitizers (PS) are presented. The kinetics of photodynamic therapy (PDT) for both oxygen-mediated (type-I) and non-oxygen-mediated type-II will be analyzed for clinical efficacy, which is influenced by the PS and oxygen concentration, light intensity and fluence (dose), and the clinical protocols. Both analytic formulas and numerical simulation will be presented for the dynamics and spatial profiles of the PS concentration and light intensity. Validity of Bunsen-Roscoe reciprocity law and the conventional Beer-Lambert law will be discussed for specific clinical systems. Higher light intensity offers faster procedure but suffers lower efficacy, which may be overcome by a novel PS concentration-controlled method. Theoretical predictions and reported clinical outcome will be analyzed and compared via the key factors of crosslink-time, crosslink-depth and crosslink-strength (or efficacy). In addition to a Review, we will also present some new experimental data based on in vitro phototherapic destruction of cancer cells. Finally, various strategies for the improvement of PDT efficacy including synergic process with photothermal therapy (PTT), control of light path, and control of PS concentration profile, will be presented. This Chapter intends to provide useful clinical guidance, predicted optimal protocols and the bridge between basic theory and measured data, besides the new directions exploring potential medical applications of photopolymerization using lights (LED or lasers) at various wavelength range of UVA to near-IR.

Keywords: photodynamic therapy, photosensitizers, cancer therapy, ophthalmology, corneal cross linking.