

the variability of processing procedure and protein stability, Forbes et al. (2007) determined that spray-drying causes perturbations in the secondary structure of trypsin [65], and French et al. (2004) found that spray-drying of recombinant human granulocyte colony-stimulating factor (rhG-CSF) and recombinant consensus interferon- α (rConIFN) with trehalose stabilized their α -helical structures which were also compromised by the spray-drying processing in the absence of trehalose [66]. While these studies and others [67] report changes in the secondary structure of proteins or peptides due to spray-drying, Schule et al. (2007) reported no detectable changes to humanized chimeric monoclonal antibody (IgG1) which could be attributed to spray-drying [67]. While they demonstrated antibody aggregation in the presence of high sugar contents (60–80% mannitol) and secondary structure changes resulting from thermal stress (80–90 °C), no change in secondary structure associated with spray-dried mannitol-containing formulations could be detected. Even though generalizations may be drawn among similar biomolecules, these examples demonstrate that the type of denaturation and/or aggregation resulting from spray-drying is protein-specific and that stabilizing excipients must respond to the specific sensitivities of the biomolecule under investigation.

Applications of Spray-Dried Biopharmaceuticals

While it is outside the scope of this chapter to fully catalog the range of biopharmaceuticals currently under investigation as spray-dried formulations, we hope to illustrate the flexibility of the spray-drying process in formulating sensitive compounds by highlighting particularly strong lines of research within the realm of spray-dried biomolecules—namely, pulmonary delivery, vaccine research, and diabetes research. The overlap among these fields of research will hopefully give the reader a greater understanding of the interplay between spray-drying processing parameters and the effectiveness of the final product. While the predominant application of spray-drying in the field of biopharmaceutical development is the use of spray-drying to formulate aerosolized therapeutics for pulmonary delivery, it is not the only application of spray-drying for biopharmaceuticals, and several reviews of spray-dried biomolecules exist [68].

Spray-Dried Biopharmaceuticals for Pulmonary Delivery

Most biopharmaceuticals rely on parenteral delivery, but pulmonary delivery affords several advantages, including reduced discomfort to the patient, fewer health-care professionals needed for delivery in low-income countries, improved patient compliance, avoidance of first-pass metabolism, and rapid onset of action [69, 70]. The pulmonary delivery route also exhibits a large absorptive surface area ($>100\text{ m}^2$), high vascularization, and alveolar epithelium as thin as $0.1\text{ }\mu\text{m}$ [71, 72]. The utility