Lipid nanoparticles (LNPs) are potent delivery vehicles that have accelerated the translation of RNA therapeutics and led to the FDA-approval of mRNA COVID-19 vaccines. However, one major barrier that has prevented researchers from unlocking the full potential of LNP-based therapies is the low sensitivity of current characterization techniques, which rely on bulk analysis of LNPs. These techniques cannot evaluate essential parameters, such as RNA loading distribution, particle morphology in ambient conditions, and the percentage of unloaded LNPs, which are critical features to monitor for pharmaceutical development. In this study, we combine standard characterization techniques with a multitude of advanced characterization techniques, including multi-wavelength analytical ultracentrifugation (MWL-AUC), size exclusion chromatography-small angle X-ray scattering (SEC-SAXS), and size exclusion chromatography-multi-angle light scattering (SEC-MALS), to: (1) compare the resolution of each technique and (2) elucidate the advantages and disadvantages for each technique for LNP analysis. As a demonstration of the enhanced resolution of these advanced characterization techniques, we will compare clinically relevant LNP formulations when prepared by either microfluidic rapid mixing or bulk mixing, which are two common methods for small-scale LNP production. With current characterization techniques, it is difficult to assess the quality of new formulation methods; however, these advanced characterization techniques were able to provide insight into how these preparation methods affects LNP structure and RNA loading. Additionally, by combining these techniques together, we demonstrate the effect of mRNA size on RNA loading distribution. The characterization techniques employed here can enhance our understanding of LNP structure-property-function relationships and enable researchers to precisely define their RNA LNP products, which can improve LNP quality and potentially accelerate pharmaceutical development.