ABSTRACT


Throughout the wet granulation literature granule microstructure is used to describe the initial formation of granules, explain the growth patterns of granules, and to predict final granule performance. However, after a thorough review of the literature, granule microstructure is only described by the average granule porosity. The use of the average granule porosity in models assumes that the internal structure of granules is homogeneous which has been shown to be untrue. This thesis hypothesizes that the average granule porosity is an over simplification of the granule microstructure and that the internal distribution of phases (particle, liquid, and air in wet granules; particle, binder, and air in dry granules) will have a substantial effect on the development and performance of granules.

In order to investigate this hypothesis, methods are developed to describe the granule microstructure in 3D space. The use of X-ray computed tomography (XRCT) along with image analysis techniques are used to isolate the particle, binder, and internal air volumes in dry single granules for the first time. After phases are isolated, methods to describe the internal distribution of particle, air, and binder are created. Descriptions of the
internal distributions of particle, air, and binder show that phase fractions vary depending on the location within the granule.

The internal granule measurement methods are then used to describe the initial internal structures of granules formed in different ways. The phase distributions inside granules depend on both the formation method and drying method. Granules formed on a static bed show homogeneous particle and void fractions within the core of the granules. However, the binder distribution is dependent on the drying method of the granule with binder preferentially solidifying near surfaces that are exposed during drying. Formation of initial granules in a fluid bed shows that the initial particle and void structures are not homogeneous with larger particle fractions located at the periphery of the granule and smaller particle fractions in the core of the granules. The distribution of particles is dependent on the viscosity of the binder solution with larger particle fraction gradients formed with more viscous binder solutions. Binder also preferentially solidifies near exposed surfaces during drying of the granules made in a fluid bed.

The different granule structures are then broken by diametrical compression tests. Although the breakage data is scattered, the change in specific surface area of the granule due to fragmentation is shown to depend on the maximum binder to particle volume ratio within granules. The deformation of granules is also shown to depend on the internal structure of granules with granules with porous cores requiring less energy to deform the granules.
Through these studies, the hypothesis that average granule porosity is an over simplified descriptor of granule microstructure is proven. Therefore, the study of granule microstructure requires further research.