Fumed silica is routinely used as a flow aid in industries such as food and pharmaceutical due to its chemical inertness, as well as wide availability in multiple grades. However, the properties of these grades vary and it can't be assumed that they will all have the same influence on bulk behaviour when blended with a wide array of different substrates and other additional components.

A robust method of quantifying the effect of different grades of fumed silica and the influence that has on performance in a manufacturing operation enables a design space of acceptable properties for raw materials and blends to be established. In the pharmaceutical industry in particular, this approach is fundamental to Quality by Design (QbD) but relies on material characterisation techniques that provide repeatable, robust and relevant data.

MULTIVARIATE ANALYSIS OF SILICA BATCHES

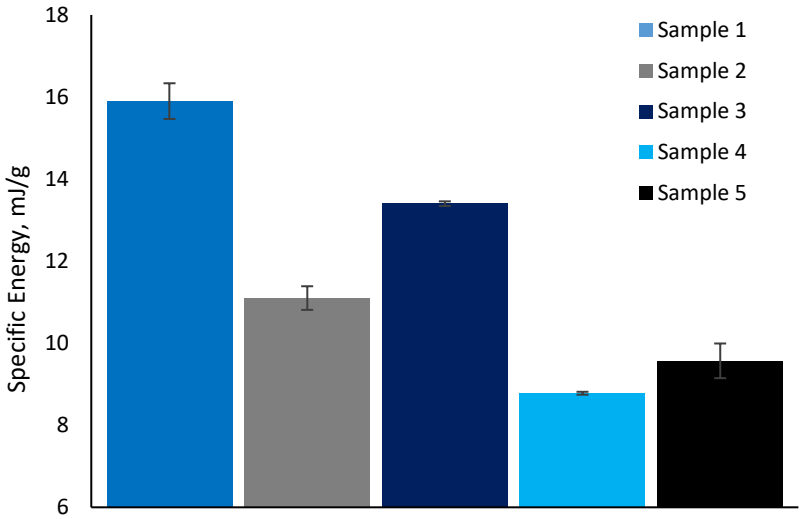
Five grades of untreated fumed silica with similar particle size distribution and D_{50} from a range of suppliers were analysed using an FT4 Powder Rheometer® to evaluate their Dynamic Flow, Bulk and Shear properties.

TEST RESULTS

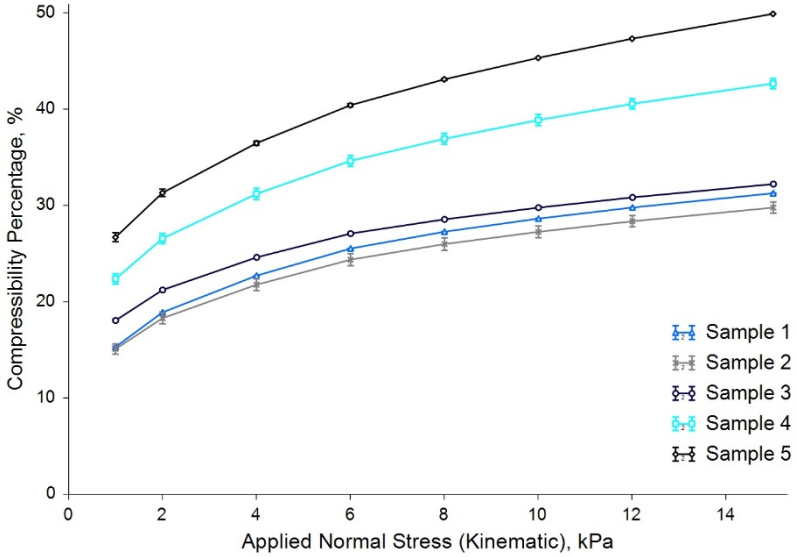
Dynamic Testing: Specific Energy

Specific Energy (SE) is derived from a dynamic test that measures the resistance of particles moving relative to one another in an unconfined state. Sample 1 generated the highest SE of the five materials, and Sample 4 the lowest.

High SE represents a greater degree of mechanical interlocking and friction within the bulk, typically leading to problems in operations such as mixing, where interlocking and friction can limit dispersal throughout a bulk substrate.



Bulk Testing: Compressibility



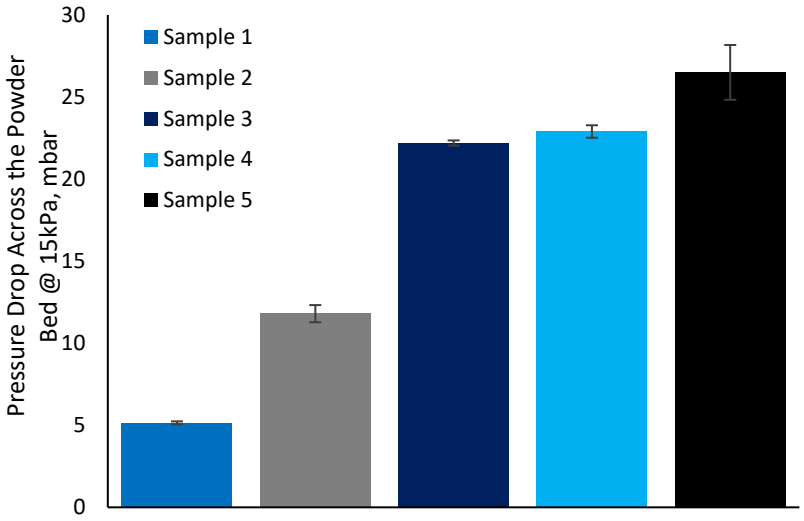
Sample 5 was the most compressible of the materials, indicating that if stored in large quantities, it would be more susceptible to consolidation. High Compressibility indicates that a powder entrains a greater proportion of air within its bulk, which is a property typically associated with more cohesive, inefficiently packed powders.

Lower Compressibility was observed for Samples 1, 2 and 3, suggesting that they would exhibit less consolidation, and therefore may be more suited to longer term storage under higher levels of stress.

Bulk Testing: Permeability

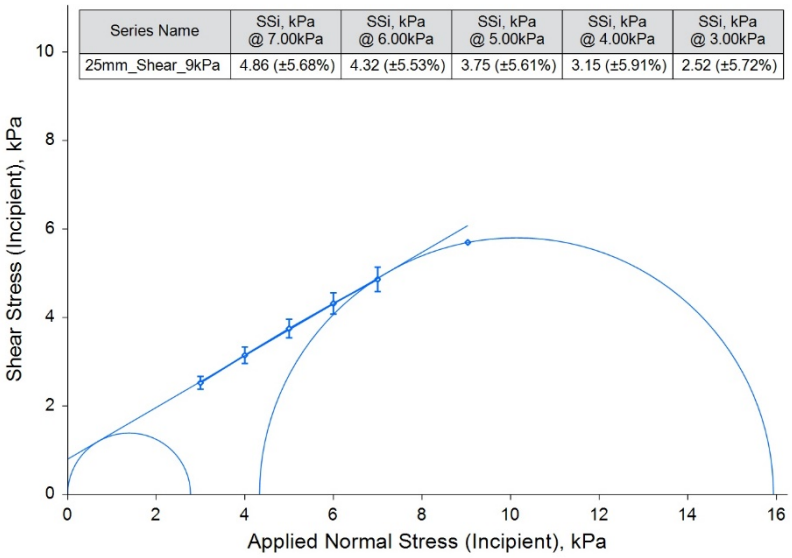
Sample 5 generated the highest Pressure Drop across the Powder Bed under a constant throughput of air, indicating that this was the least permeable of the samples. Sample 1 generated the lowest Pressure Drop, indicative of the highest permeability.

Low permeability can contribute to poor performance in operations where a powder is required to release entrained air, such as die filling and tableting, and can adversely impact gravitational flow in general.



Shear Cell Testing

Series Name	SSi, kPa @ 7.00kPa	SSi, kPa @ 6.00kPa	SSi, kPa @ 5.00kPa	SSi, kPa @ 4.00kPa	SSi, kPa @ 3.00kPa
25mm_Shear_9kPa	4.86 (±5.68%)	4.32 (±5.53%)	3.75 (±5.61%)	3.15 (±5.91%)	2.52 (±5.72%)



Minimal differentiation was observed between the five samples. Near identical Shear Stress values were generated (RSD <6%).

This lack of differentiation illustrates that Shear Cell testing, designed to investigate how a powder transitions from a static to dynamic state following consolidation, may not be a suitable method to predict performance in dynamic, low-stress operations.

CONCLUSION

Selecting a suitable grade of fumed silica can enhance flowability in the required manner for a given process. However, this requires an understanding of how the all of the ingredients behave, as individual components and as part of a mixture.

Clear and repeatable differences are observed in the between the Dynamic and Bulk properties of the five grades of fumed silica, suggesting a likely difference in performance when blended with bulk materials. This is not identified by assessment of particle size alone.

Powder flowability is not an inherent material property, but is more about the ability of powder to flow in a desired manner in a specific piece of equipment. Successful processing demands that the powder and the process are well-matched, and it is not uncommon for the same powder to perform well in one process but poorly in another. Multi-faceted characterisation provides an essential foundation for understanding the variable behaviour of powders, enabling the properties that are most relevant to in-process performance in any unit operation to be identified and quantified.

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