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Flexible Fused Silica Capillary: A Discussion of Strength >

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Synthetic fused silica capillary tubing is a vital component in many scientific techniques. The general perception is that most laboratory glass products are fragile and easy to break. The opposite is true of fused silica capillary; with its protective coating it is both strong and durable when handled properly.

Introduction

Researchers routinely use synthetic fused silica capillary in performing GC, CE, Capillary LC, Cytometry and related analytical analysis techniques. Regardless of the application, the fundamental question of capillary strength often arises. This note discusses fused silica capillary tensile strength, strength testing and the key user activities that can impact strength.

Fused Silica Strength

Flexible synthetic fused silica capillary tubing is drawn from high purity, low metal ion content Silicon dioxide preforms. In most cases the fused silica tubing is externally coated with an abrasion resistant material such as polyimide; this coating protects the surface from external damage, resulting in a durable high-strength product. The theoretical tensile strength based on Si-O bond energy calculates to be ~2,000kpsi. The empirical strength of fused silica has a lower value due to minor imperfections within the amorphous structure and at the surface; a typical value is ~700kpsi.

Strength Testing and Screening

The most common method employed for determining capillary strength is a tensile test. This destructive test is performed on a Tensile Tester, such as an Instron Model 3344 (Instron, Norwood, MA). A section of tubing ~2m in length is loaded into the device and then pulled at a defined strain rate, typically 0.25m/min, until failure occurs. The load at failure is recorded for a sample set of 20, with the corresponding statistical data presented in the form of a Weibull Plot. (1) Alternatively, a two-point bend test can be performed wherein the radius of the bend at failure is recorded and the corresponding tension is back calculated using Young's Modulus. It should be noted that the measured strength will decrease as the glass substrate increases in size; larger material is statistically more likely to contain a failure inducing imperfection.

Strength screening is of equal importance in capillary manufacturing. A bend radius test in no less than two axes is performed in-line during the draw process. The capillary is routed through a series of rollers; their diameter is selected to correspond to a desired stress level. The

technique is called Proof Testing, with the typical applied stress being 100kpsi. This approach allows for 100% screening, as the test is not destructive. For comparison, 0.53mm i.d. capillary placed on a typical 8" GC cage will experience ~30kpsi of stress.

A common misconception is that bend radius screening is related to internal pressure capability; no such relationship is suggested here. Pressure testing would be a separate evaluation; the topic has been discussed previously. (2)

Common Factors Which Impact Strength

Anything that will cause a flaw to form in the fused silica should be considered. The most common factor is improper handling, wherein the protective coating is inadvertently penetrated and the underlying fused silica surface compromised. Introduction of debris into the capillary may damage the internal surfaces, which will immediately compromise strength. Common causes are poor cleaving technique, use of unfiltered reagents and dirty components upstream in the flow path, including residue from cleaving. (3) Exposure to atmospheric gases, including water, over time will result in an aging effect by accelerating the propagation of surface imperfections. This is why the capillary is sealed with an inert gas inside upon manufacture. (4)

Conclusion

Polyimide coated fused silica capillary is a very strong material. It is continuously monitored for strength during its manufacture by proof testing. With proper handling and usage, it will retain excellent strength in most applications. For specific questions, contact a Polymicro Technical Specialist.

References

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