

## **A simple and effective capsule sealing technique for hydrothermal experiments**

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### **ABSTRACT**

Capsule sealing has always been a key procedure in hydrothermal experiments to explore the composition and properties of geo-fluids and their influence on various geological processes. Previously reported capsule sealing techniques have primarily focused on either weld-sealing or cold-sealing methods, which have some disadvantages and limitations. Here, we report on a newly developed, simple, and effective capsule sealing technique incorporating operations from the cold-sealing and weld-sealing techniques. The technique includes three steps: first, preparing inner and outer tubes, both with a flat bottom at one end; subsequently, reverse-buckling the tubes to form a preliminary seal; and finally, welding shut the tiny slit at one end of the tubes. The new capsule sealing technique was tested in experiments for fluid inclusion synthesis. Fluid inclusions were successfully synthesized in 10 runs over a range of conditions (800–900 °C, 1–1.5 GPa). Considering the insignificant mass changes recorded and the occurrence of free fluid from the recovered capsules, the new capsule sealing technique was proven to be reliable. The simple and effective capsule sealing technique has the following advantages over the previous techniques. First, the capsule sealing technique is simple, effective, and easy to operate. The technique does not require a capsule body and lid with a complex structure, nor does it require dies or special tools. The critical weld-sealing operation is easier to complete due to the narrow and uniform slit surrounded by more metal, during which loss of volatilization is prevented by the preliminary seal. Second, the capsules can be sealed with uniform thickness and regular shape, prechecked for leakage in an oven, and annealed under high temperature and high pressure with less deformation, which could improve the success rate of experiments. Third, the theoretically required capsule materials can be changed (such as precious metals, alloys, etc.), as can the dimensions required to construct a capsule with the desired size and wall thickness (large volume or thick wall). Thus, sealed capsules are suitable not only for piston cylinders but also for multi-anvil presses and other gas-media or hydrothermal-media apparatus, such as autoclaves and pressure vessels, which means a wider range of temperatures and pressures are accessible and thus more fields of application.

**Keywords:** Capsule sealing, cold-sealing, weld-sealing, hydrothermal experiments, fluid inclusion synthesis