INVESTIGATION OF THE COMBUSTION OF SILICON PARTICLES IN AIR AND THEIR REACTION PRODUCTS

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Abstract

To achieve climate neutrality, we will have to completely abandon coal as an energy source in the near future. Without coal-fired power plants, however, and if we want to avoid nuclear power at the same time, it will be difficult to guarantee the base load share of the national electricity supply. One conceivable alternative could be a replacement of coal by using metal particles as fuel. Metal particles could be burnt in a very similar technical process. Possibly even part of the infrastructure needed for this could be taken over from existing coal-fired power plants. Silicon offers itself as a particularly suitable carbon-free energy source. As the second most abundant element in the earth's crust, it is omnipresent, especially in the forms of stone. As combustion product, SiO_2 should be produced again, which ideally can be reused, e.g., as raw material or construction material. Thus, like hydrogen, silicon fulfils the requirement for a universal energy carrier that it does not have to be collected again for recycling. Although silicon has long been used as a pyrotechnic fuel, its combustion and the nature of the resulting products have hardly been studied. This is especially true for the combustion of silicon dust with air.

In this study, a stationary combustion in air was generated for the first time. The vertical flame was stabilised with a hydrogen-oxygen burner into which three types of silicon with different particle sizes (10&50µm, 50 µm, 100 µm) were injected as cross flow. The particle velocity at the pilot flame was about 30 m/s. A stationary dust flame in air formed above the horizontal pilot flame in all cases. The average flame length

was about 60 to 80 mm with silicon particles of 50 and 100 µm. The bimodal mixture produced a somewhat shorter flame. Combustion temperatures measured by emission spectroscopy were largely independent of the Silicon particle size at about 2000 K close above the pilot burner. It dropped to about 1700 K by the end of the flame. This corresponds approximately to the melting point of silicon at 1687 K. The burner was not optimised. Product samples have shown that especially large silicon particles were not ignited by the support burner due to the high particle mass flow and a too high particle density in the centre of the particle jet. However, a large part of the silicon was completely converted into pure silicon dioxide in the form of fumed silica. The product is found as an aerosol in the exhaust gas stream. In a technical combustion process, it can be collected as condensed material from the smoke gas for further use.

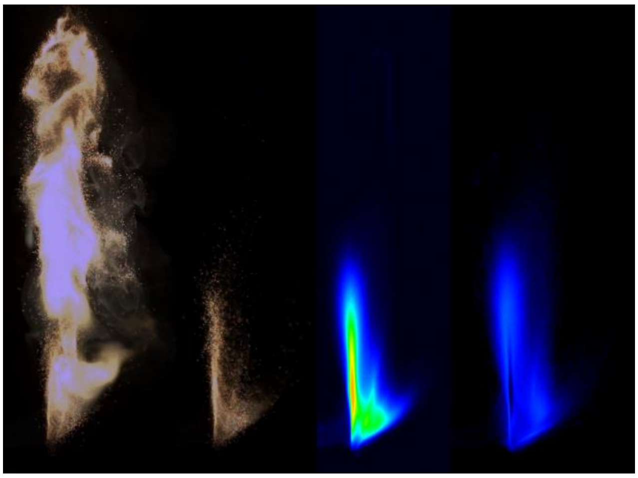

Figure 1 Steady-state silicon flame: (a) frame of ignition, (b) frame of steady-state flame, (c) mean value of steady-state flame and (d) standard deviation of steady-state flame.

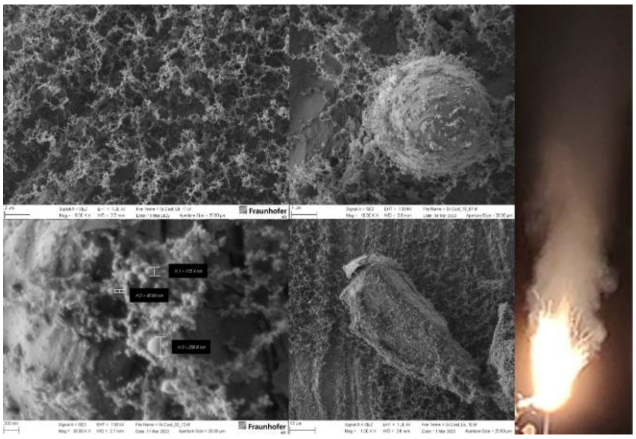

Figure 2 Combustion products: left SEM-images, right product stream