EDUCATIONAL HEAT FLUX DIFFERENTIAL SCANNING CALORIMETER "KOLIBRI-1.1"

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One of the goals of the educational process is to help students acquiring practical skills in their chosen field. In this regard, the importance of various practical training sessions, demonstration and laboratory work, research activities, educational research projects, etc. cannot be overestimated. The level and feasibility of all these activities are largely determined by the state of the educational institution's resources, i.e., the availability and condition of existing instruments and equipment.

Considering thermal analysis as a broad area of expertise, it is regrettable to note that in most cases, student experiences in this field are limited to constructing cooling curves for alloys, which is typically included in laboratory practical training for general courses of physical chemistry. Some time is provided for teaching modern calorimetry and thermal analytical equipment in various specialized courses, but to a much extent this remains largely theoretical. Practical and (most importantly) independent training on modern instruments is usually limited and not widespread. This is largely due to their high cost and limited resources for spare parts and repairs, and recently, in some cases, the impossibility of such repairs due to geopolitical reasons. Therefore, a pressing task is the development and creation of training instruments that are as close as possible to full-featured professional instruments in their capabilities, characteristics, software, and operating features, while being significantly less expensive.

This report will present the results of the development of such an educational instrument – the Kolibri-1.1 heat flux differential scanning calorimeter. The device is designed for thermal analysis and measurements of thermodynamic characteristics (temperature and enthalpy of phase transitions, heat capacity) of solid, powdered, and liquid materials, as well as for constructing phase diagrams. The calorimeter is a benchtop laboratory instrument consisting of a heating furnace, a three-position calorimeter cell, a cooling system, an analog-to-digital converter combined with an amplifier and data acquisition system and is controlled by an external computer. The design of the three-position calorimeter cell allows for the simultaneous measurement of two samples relative to a single reference sample.

The operating temperature range is 25–200 °C, the heating rate range is 0.5–10 °C/min, the DSC sensor sensitivity is 110 μV/mW, the resolution is 0.01 mW, the noise level (RMS for 1 hour at 100 °C) is 0.045 mW, and an emergency protection system is available in case of overheating of the measuring unit.

A practical course on thermal analysis was implemented using the manufactured calorimeter prototypes; the laboratory work on melting diagrams was modernized as part of the general course in physical chemistry; and laboratory work on thermal analysis was conducted at the Sirius Educational Center as a part of the thermodynamics educational program.