# Quantitative characterization of vapour adsorption on solid surfaces and estimation of emissivity of solids using infrared thermography

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Oral presentation.

Infrared thermography provides a means for combining real-time visualization with quantitative analysis. One of the best conditions for the application of infrared camera to be applied is when heat is generated in the immediate region of a surface of a body. In the present work the last situation was maintained. It is sampled in studies of water vapour adsorption on uneven (irregular) surfaces of solid materials. Deposition of molecules onto any type of surfaces from a gas (vapour) phase (adsorption, condensation) is of considerable current interest and use in many scientific and technical applications. It plays a crucial role in heat exchange processes, biochemical systems, etc. Of special interest is the study of adsorption mechanisms of water [1, 2].

In the present work, we studied the release of heat in non-equilibrium process of deposition of fast molecules escaped from liquid (water) to the nearby surface of solid bodies of variable chemical compositions and topological structures. Multiple swatches taken from a set of different fabrics served as experimental samples. The effect of fabric heating during adsorption first illustrated in [3] is investigated thoroughly. A distinguishing feature of the effect investigated in the present work is the pronounced rise of temperature of a fabric (or absorbent paper) surface in a quite limited zone near the front of the liquid. Propagation of this "thermal fire" in radial direction from the moment of local moistening of fabric (flannel) stretched aflat is shown in figure 1.

Table 1 (middle column) represents several characteristic values of excess $\Delta T$ of ribbon temperature $T$ at the maximum with respect to temperature $T_B$ in a ribbon point located far from the fabric-liquid interface. Values of $\Delta T$ are refined in view both of formula

$$T - T_B = \frac{T_M - T_B}{\varepsilon} \qquad (1)$$

and of the experimentally obtained values of emissivity $\varepsilon$ given in the right column of table 1. In (1) $T_M$ is the temperature displayed by IR system (instead of a real temperature $T$). Simple formula (1) is derived in view of the fact that we operate with narrow-band infrared camera. A narrow spectral range short-wavelength IR camera described in [4] was used in the experiments.

A method allowing evaluation of emissivity from reflection measurements equipped with a narrow-band infrared camera is presented, and formula

$$\varepsilon = 1 - \frac{1-\varepsilon_{\mathrm{d}}}{T_{\mathrm{Md}} - T_{\mathrm{B}}}(T_{\mathrm{M}} - T_B) \qquad (2)$$

is obtained. In (2) $\varepsilon_{\mathrm{d}}$ and $T_{\mathrm{Md}}$ are respectively the values of $\varepsilon$ and $T_M$ taken for material with known $\varepsilon$ (datum point).

A sharp distinction between adsorptivities of fabric surfaces is strikingly illustrated by table 1 exhibiting the associated thermal effect ranged within the order of magnitude. On the basis of the presented results the attention is called to the need for close control over the surface temperature increase while the adsorption isotherms are being measured.

Sensitivity of the FPA-based IRT method as applied to examine the kinetics of initial stages of adsorption of gaseous molecules on solid surface is evaluated analytically and quantitatively. The relationship between the amount of adsorbate and measurable excess of adsorbent temperature is found. It is discovered that the method makes it possible to control nano-quantities of adsorbed matter, namely, it is sensitive to incipient molecular film of less than 1/100 monolayer effective thickness.

## REFERENCES

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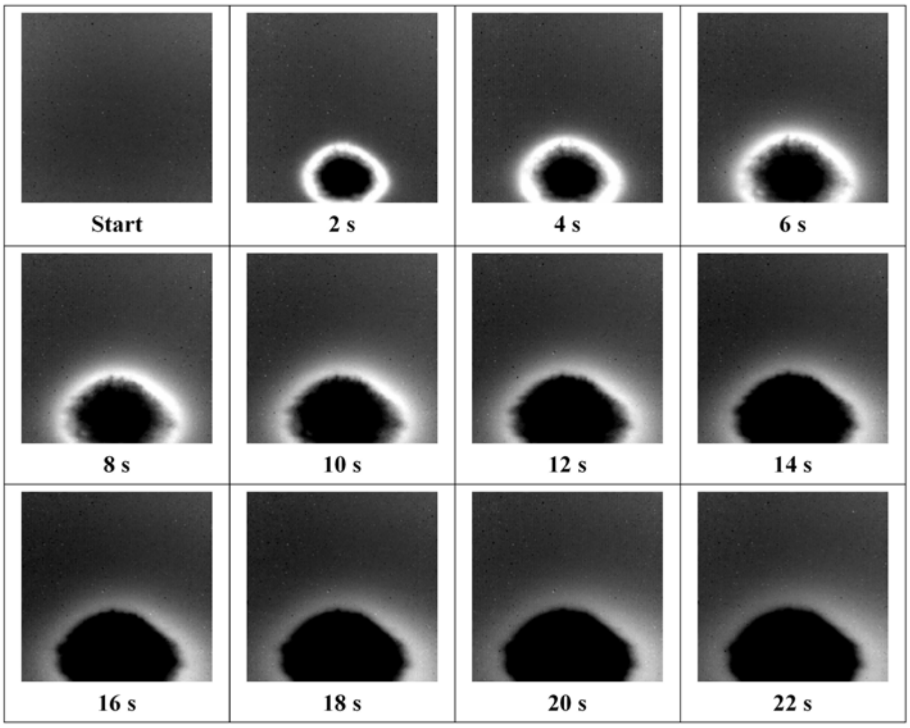


***Fig. 1.*** *"Thermal fire" phenomenon on the flannel surface stretched aflat. The time elapsed since fabric moistening is indicated under corresponding thermogram.*

***Table 1.*** *Experimentally obtained parameters of different fabrics.*

| **Fabric** | **max** $\Delta T$, °C | **Emissivity** ( $\lambda$ = 2.8 μm ) |
|---|---|---|
| Polyamide | 0.59 | 0.692 ± 0.012 |
| Factory cloth tape | 2.41 | 0.722 ± 0.012 |
| Crinoline (linen) | 2.66 | 0.732 ± 0.002 |
| Velveteen (thin) | 2.90 | 0.756 ± 0.008 |
| Jean (composite cloth) | 3.04 | 0.813 ± 0.013 |
| Silk cloth | 3.22 | 0.749 ± 0.012 |
| Velveteen (thick) | 3.55 | 0.750 ± 0.015 |
| Polyester | 3.86 | 0.7 (datum point) |
| Half-woolen cloth | 3.98 | 0.780 ± 0.006 |
| Thick woolen (100%) cloth | 4.38 | 0.762 ± 0.013 |
| Poplin (cotton) | 7.75 | 0.710 ± 0.013 |
| Flannel | 8.06 | 0.668 ± 0.008 |