JPMTR-2308
DOI 10.14622/JPMTR-2308
UDC 54472-035.4

Position paper | 181
Received: 2023-06-27
Accepted: 2023-07-07

What about the surphase?

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Abstract

We talk glibly of the *surface* of paper, even when we are talking e.g. of paper strength, where we should more correctly talk of the s*urphase* strength. The strength is related to a material layer not to a geometrical surface.

Keywords: paper science, terminology, surface properties, bulk layer properties

This brief contribution is a plea for the recognition and use of the term "surphase" rather than the more familiar "surface" when the intention is to refer not to the mathematically defined surface but rather to a layer of material in the surface region.

Dr Mladen Lovreček, a former Secretary General of the IARIGAI, used to enjoy talking of how his friendship with me as Technical Editor of the Conference Proceedings had developed from an initial debate and disagreement as to whether in one of his conference papers he should refer to the "*interface*" or to the "*interphase*". He has indeed referred to this debate with humour and a certain degree of imaginative speculation in his contribution to the IARIGAI memoirs published a few years ago (Lovreček, 2018). Our discussion was stimulating and we reached an amicable conclusion, but the details of the discussion are unimportant. The important fact, which I wish here to document, is that both these words exist and that their different geometrical interpretations are well understood. A spontaneous *interface* may arise between two immiscible phases, but miscible liquids may intersperse and interact or an adhesive may be applied to create what is recognised as an *interphase.*

I have therefore wondered for years why we do not with the same enthusiasm and with the same desire for accuracy distinguish between the "*surface*" and the "*surphase*" of a medium or an object, particularly in the field of paper science. A *surface* is essentially a mathematical concept which can be defined in geometrical or trigonometrical terms, whereas a material layer capable of possessing physical properties surely deserves instead to be called the *surphase*.

I must perhaps emphasize that I wish to restrict the use of the term "*surface*", using it not as a synonym for the material layer which constitutes the *skin*, but to describe a topological two-dimensional region with no thickness and no volume, a linguistic and mathematical difference which has apparently not always been recognised in the discipline of surface science. According to my definition, surface science is a discipline which is strictly limited to the study of the interface between an object and the surrounding ambient medium and not to the properties of any surface layer with a finite thickness.

We are perhaps not offended by references to the *surface tension* of a liquid for we realise that this is indeed a property which can be related to the surface and not to the bulk liquid, but I have never really liked the way in which we calmly talk of the *surface strength* of paper.

When considering the behaviour of a web of paper or of sheets of paper in a printing press and the need to keep the press clean of dust and fibre particles, we are conscious of the fact that there is a measurable strength associated with the surface and that we expect the papermaker to take the necessary steps to ensure that the strength is sufficient for our purposes.

This has led to much work in many countries and in many institutes to define, measure and ultimately improve what has become known as the *surface strength*, but this is the strength not of a mathematical concept but the strength of a thin layer of material – often a multi-component layer – which forms the paper *surphase*, and we should surely refer to it instead as the *surphase strength*.

Although the word has not been used in the field of paper physics, the word "*surphase*" is not in fact unknown to the scientific community. A group working in Vietnam, for example, has used the term when reporting the use of *surphase resonance* to study the properties of a gold nanoshell deposited on a nanoparticle core (Lien, et al., 2018). These authors realise that a gold nanoshell deposited on the *surface* creates a *surphase.*

At an early stage in the development of paper physics as a scientific discipline, there was a lot of interest in measuring the *surface roughness* and various methods were developed to measure this property, of which the Bendtsen method using air-flow across the surface became the most frequently used, although it felt counter-intuitive to express roughness in *ml/min*. In the 1960s, however, John Parker advanced this idea to produce the Parker Print Surface (PPS) instrument (Parker, 1971) where an important development was the consideration of the relationship between the air flow and the gap size so that the air flow data could be converted to and presented in µm, which could be interpreted as the mean distance between the surface and a reference plane tangent to the surface.

Consideration of what actually happens in a printing press led to the concept of compressibility and to the need to distinguish between the bulk compressibility of the paper sheet and the compressibility of the surface region, and I believe that I was one of the first to publish data on a property which I referred to as the *surface compressibility* (Bristow, 1982a; 1982b) where I used a modified PPS-instrument with an attachment so that I could adjust the pressure applied to the surface when the air-flow measurement was being made.

With increasing pressure, the surface roughness diminished, but I did not then state clearly that, when considering this to be a compressibility measurement, I was in fact no longer interpreting the PPS-value as the mean distance between the paper surface and a reference plane but rather as the mean thickness of the layer between the reference plane tangent to the surface and a reference plane defined by the bottoms of the depressions in the surface, i.e. as a measure of the thickness of a surface layer and I should therefore have referred to the compressibility of this surface layer as the *surphase compression.*

This manner of thinking can be applied to other properties. We measure the *surphase abrasion* and a *surphase puncture factor*, but we refer correctly to a *surface indentation* where the surface is deformed but where there is no physical damage.

Optical properties such as brightness, whiteness and opacity may be independent of the surface, but printability properties such as *print density* and especially *print through* are the result of an interaction which involves the *surphase* rather than merely the *surface.*

When studying printability and the interaction between ink and paper, I became involved in the field of perceptual psychology and there I learned that it is often necessary to distinguish between body colour and surface colour but, without entering into a deep discussion of the phenomenon of colour and its perception, we can here note that the two main types of colour, structural colour and pigment colour, involve material structure and that it may thus be argued that *surface colour* should, according to my current thesis, properly be called *surphase colour.*

An understanding of this is evident in a paper by Vega et al. published in the American Journal of Analytical Chemistry (Vega, et al., 2011) where the authors refer to the use of *solid surphase fluorescence.* Fluorescence involves an interaction which is, of course, a *surphase* phenomenon not a *surface* phenomenon.

The discussion can be extended to other properties, and I am, of course, interested to see what the response to this plea may be. I hope that the discussion will not be merely superficial, or should I perhaps say "superphisial"?

Dedicated to the memory of Prof Pierre Lepoutre (1933–2020) Montreal, expert in paper properties.
Many years ago, I promissed him that I would one day write this article.

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