Sorption vs Adsorption: the words they are a-changin', not the phenomena

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If your time to you is worth savin'

Then you better start swimmin'

Or you'll sink like a stone

For the times they are a-changin'

Robert A. Zimmerman, a.k.a. Bob Dylan (2016 Nobel Prize in literature)

The Times They Are A-Changin' (song, 1964)

Adsorption, the accumulation of matter at the solid-water interface, is the basis of most surface-chemical processes (Stumm and Morgan, 1996). However, the terms sorption and adsorption are often confused and misused in many articles (Tien, 2006; Tran et al., 2017). Even if one thought their formal definition is well known, this does not appear to be the case.

The word "adsorption" was coined in 1881 by German physicist Heinrich Kayser.

According to IUPAC (1997) adsorption reflects an increase in the concentration of a substance at the interface of a condensed and a liquid or gaseous layer owing to the operation of surface force, whereas sorption is a process by which a substance (sorbate) is sorbed (adsorbed or absorbed) on or in another substance (sorbent).

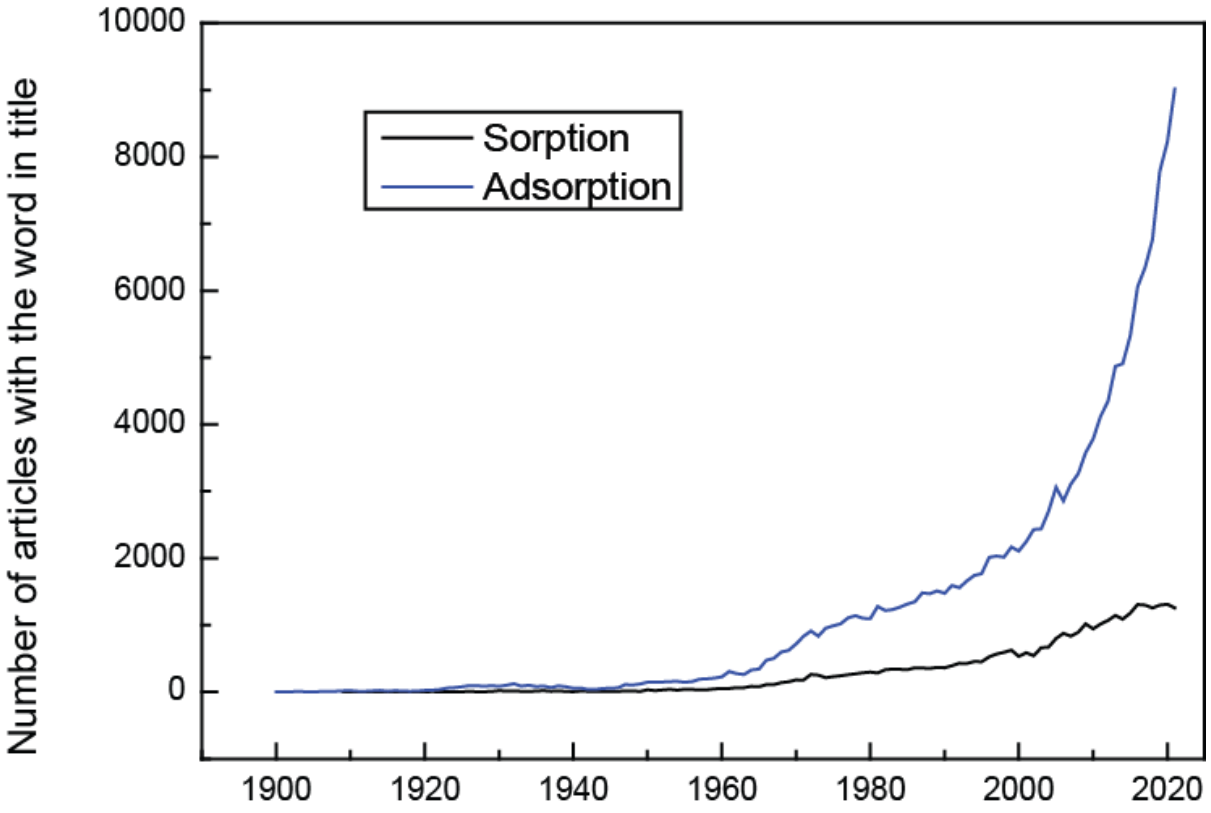

Figure 1 Evolution of the number of articles using the terms “adsorption” and “sorption” in their title (source Web of Science, 22/04/2022).

Apart from these “official” definitions, adsorption is often defined as a molecular-scale process. Sorption is often considered as a vague term describing the partitioning of a

dissolved species to the solid phase via an unspecified (or hypothesized) mechanism and according to some authors should no longer be used, as highlighted in some journals (e.g. *Environmental Science & Technology,* from Web of Science search on 22/04/2022*)*. As highlighted on Figure 1, the number of articles with “adsorption” in their title continue to increase (9015 in 2021, like the overall number of scientific articles), whereas the number of articles with “sorption” in their titles appears to have reached a plateau, even starting to show a decrease (1256 in 2021). A few authors used both terms in their titles (15 articles in 2021).

However, as seen in *Chemosphere* or *Journal of Hazardous Materials*, articles published in *Science of the Total Environment* continue to use the term “sorption” in their title (29 articles in 2021). It appears that “adsorption” is a more appropriate term in most of the cases. Indeed, adsorption is the partition of ions to the surface, via various mechanisms, where sorption is the general partitioning to the solid phase which may include adsorption, absorption and surface precipitation, to some extent. In the same time, 90 articles used the word “adsorption” in their title. While most of the authors used this term correctly, some include the term adsorption instead of sorption, perhaps because data to provide a definitive statement was not collected or available.

A quick overview of research areas (Tables 1 and 2) where both words were used in 2021 shows that perhaps unsurprisingly Chemistry and Engineering are the major research areas using those terms. The third category using the word “adsorption” is Material Science whereas the third one using “sorption” is Environmental Sciences Ecology. The word “sorption” is proportionately more frequently used in the Environmental Science Ecology research area. Moreover, Agriculture field mostly used the word “sorption”, whereas Toxicology mostly used the word “adsorption”.

Table 1 First ten research areas from articles published in 2021 with the word sorption in their title (n=1256; source Web of Science, 22/04/2022).

Research area	**Number of articles**	**Proportion**
Chemistry	590	47%
Engineering	541	43%
Environmental Sciences Ecology	459	37%
Materials Science	338	27%
Public Environmental Occupational Health	288	23%
Energy Fuels	242	19%
Agriculture	210	17%
Water Resources	209	17%
Physics	200	16%
Science Technology Other Topics	196	16%

Table 2 First ten research areas from articles published in 2021 with the word adsorption in their title (n=9015; source Web of Science, 22/04/2022).

Research area	Number of articles	Proportion
Chemistry	4856	54%
Engineering	4112	46%
Materials Science	3114	35%
Environmental Sciences Ecology	2922	32%
Physics	2517	28%
Science Technology Other Topics	1952	22%
Energy Fuels	1684	19%
Public Environmental Occupational Health	1629	18%
Water Resources	1499	17%
Toxicology	1007	11%

In their highly-cited review (1107 citations; source Web of Science, 22/04/2022) on the fixation of a liquid solute on a solid, Limousin et al. (2007) also suggested the following distinctions: (a) the use of “sorption” for any kind of equilibrium interaction; (b) “adsorption” and “desorption” for the description of retention and release of the solute, respectively. In many soil-plant studies, it is not possible to discriminate between adsorption and absorption without detailed supportive data and the term sorption is more appropriate to be used. Moreover, adsorption and desorption phenomena are two important parts in the chemistry of soils. In one of his articles, Jim Barrow explained why he decided, 30 years after, to move from ‘adsorption’ to ‘sorption’ (Barrow, 2008): “This word is used in a quite general and non-mechanistic way to include all mechanisms by which surfaces may remove material from solution.” The situation still seems to be difficult to reconcile and the terms are fluid in their definition and application (Barrow et al, 2022).

Further, models to describe sorption on solids are ion exchange and surface complexation (e.g. Strawn, 2021).

Eventually, mostly in biotechnology, a new term biosorption has emerged for the last ten years with about 250-300 articles with this word in their titles (262 in 2021). Biosorption is a physico-chemical and metabolically-independent process based on a variety of mechanisms including absorption, adsorption, ion exchange, surface complexation and precipitation (Fomina and Gadd, 2014).

Overall, adsorption is a surface process that leads to transfer of a molecule from a solution bulk to a solid surface whereas sorption is a less constrained process that can be either adsorption or absorption (and even surface precipitation). We thus recommend encouragement to adopt the word “adsorption” only when fully supported by appropriate data and using the “sorption” terminology when it is more speculative, typically in complex solid/solution natural systems.

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