Brazilian Journal of Analytical Chemistry
2021, Volume 8, Issue 33, pp 10-12
doi: 10.30744/brjac.2179-3425.point-of-view-lmgoncalves

POINT OF VIEW

HO^- and OH^-, Reason and Tradition

Luís Moreira Gonçalves

Departamento de Química Fundamental, Instituto de Química
Universidade de São Paulo, São Paulo, SP, Brazil

Writing OH^- is so widespread that one hardly notices that there is no logical reason, apart from being common, not to write HO^- instead. Scientists should be educated to spot irregularities, since often they mean something. Chemistry professors, in particularly at graduate level, when teaching pH should make their students notice such discrepancy.

Albeit pH is not an immensely complex topic, it is intriguing the number of misconceptions, and even plain errors, associated. For example, the limits of the pH scale [1]; it is not uncommon to find students (and not just undergrads) believing pH values cannot be lower than 1 or higher than 14, or that negative pH values do not exist. Herein, it is addressed the odd exception of writing OH^- instead of the most logical form of HO^-. It is fascinating that chemists are so accustomed to see OH^- that they do not longer find it to be an oddity.

First, it is important to highlight why it is a nomenclature exception, i.e. the lack of reason to write OH^-.

For sure, chemists are familiar with these deprotonation equations:

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$$

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

$$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$$

And this schematic equation:

$$HA \rightleftharpoons H^+ + A^-$$

And even this one:

$$H_3O^+ \rightleftharpoons H^+ + H_2O$$

So, why to write:

$$H_2O \rightleftharpoons H^+ + OH^-$$

Instead of the analogous:

$$H_2O \rightleftharpoons H^+ + HO^-$$

Why are water and the ion hydroxide treated differently? Is it because the negative charge is located on the hydrogen instead of the oxygen? No, it is not, oxygen is far more electronegative. Is it because alphabetically ‘o’ comes before ‘h’? No, it does not. Maybe it is because OH^- looks better than HO^-; or maybe because pOH would be less confused with pH than pHO. Perhaps, but these two explanations are hardly chemically meaningful.

Cite: Gonçalves, L. M. HO⁻ and OH⁻, Reason and Tradition. *Braz. J. Anal. Chem.,* 2021, *8* (33), pp 10-12. doi: http://dx.doi.org/10.30744/brjac.2179-3425.point-of-view-lmgoncalves

In fact, in the red book of the International Union of Pure and Applied Chemistry (IUPAC) [2], rule IR-4.4.3.1, it is clearly stated: *"…the formula for the hydroxide ion should be HO^- to be consistent with the above convention."*. However, precisely in the same rule, as example 11, it is stated: "HO^- or OH^-", which the author would find contradictory if 'should' were to be replace by 'must'. By the way, for the naming of the radical $HO^\bullet$, only one option is presented (rule IR-4.6.2).

To the author's limited knowledge, there is no other reason apart from historical motif. The author made an effort to better understand the question by seeking the literature, contacting a chemical nomenclature historian and an author of the IUPAC's red book. And the most probable explanation found is that many chemists (if not most of the chemists) used to write OH^- (as can be observed in many older textbooks [3-5]), and the benefits of changing to HO^- would not merit all the effort and nuisance. Thus, the reason for the title of this Point of View: tradition over reason.

Even though there are many scientists that are resilient and make an effort to write HO^- [6-10], and while their effort should be respected, one wonders if a change in paradigm would indeed have positive benefit-cost outcome. Nevertheless, the author of this manuscript advocates that it is important that students are taught that HO^- is a discrepancy. It is something worthy of Chemistry professors' endeavors. It should also be mentioned in lecture books when first referring to OH^-. And not just because it is an indulging curiosity, but because it is a 'vestigial structure' that shows the evolution of Chemistry. Furthermore, quite importantly, scientists should be trained to find irregularities, in many cases in Nature they actually mean something.

Acknowledgements

The author would like to thank Professor Richard Hartshorn (University of Canterbury, New Zealand), Professor Arnaldo Cardoso (São Paulo State University, Brazil), and Professor Rafael Mori (Federal University of ABC, Brazil) for their much-appreciated help. Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP: 2018/14425-7) is also acknowledged.

REFERENCES

1. Lim, K. F. *J. Chem. Educ.*, **2006**, *83* (10), p 1465 (https://doi.org/10.1021/ed083p1465).
2. Connelly, N. G.; Damhus, T.; Hartshorn, R. M.; Hutton, A. T. *Nomenclature of Inorganic Chemistry* – International Union of Pure and Applied Chemistry (IUPAC) Recommendation, **2005**.
3. Mori, R. C.; Curvelo, A. A. da S. *Quim. Nova*, **2014**, *37* (5), pp 919-926 (https://doi.org/10.5935/0100-4042.20140148).
4. Teixeira, J. M. *Noções de Chimica Geral* (6th Ed). Francisco Alves, Rio de Janeiro, **1906**.
5. Valeriano, T. P. do A. *Noções Elementares de Chimica Organica: Para Uso dos Alumnos d'esta Disciplina nos Gymnasios e Escolas Superiores da Republica* (5th Ed). Imprensa Nacional, Rio de Janeiro, **1921**.
6. Asthagiri, D.; Pratt, L. R.; Kress, J. D.; Gomez, M. A. *Proc. Natl. Acad. Sci.*, **2004**, *101* (19), pp 7229-7233 (https://doi.org/10.1073/pnas.0401696101).
7. Asthagiri, D.; Pratt, L. R.; Kress, J.; Gomez, M. *Chem. Phys. Lett.*, **2003**, *380* (5–6), pp 530–535 (https://doi.org/10.1016/j.cplett.2003.09.007).
8. Corrêa, C. *Bol. Soc. Port. Química*, **2002**, *85* (2), 72.
9. Barros, A. A.; Rodrigues, C.; Miguelote, L. *Química 11: Física e Química A, 11º Ano: Ensino Secundário* (1st Ed). Areal, Porto, **2013**.
10. Magalhães, P. J.; Barbosa, A. R.; Gonçalves, L. M.; Pacheco, J. G.; Guido, L. F.; Brányik, T.; Rodrigues, P. G.; Kuncová, G.; Dostálek, P.; Barros, A. A. *J. Inst. Brew.*, **2011**, *117* (2) pp 368-376 (https://doi.org/10.1002/j.2050-0416.2011.tb00481.x).

Luís Moreira Gonçalves is currently a chemistry professor in the Institute of Chemistry at the University of São Paulo (IQ-USP), São Paulo, Brazil (Research Group). He holds a BSc and a PhD in chemistry (both from the University of Porto, PT), as well as BSc in medical sciences and MSc in medicine (both from the University of Minho, PT). He previously worked as post-doctoral researcher in the Faculty of Sciences of the University of Porto, with several different research interests including psychiatry, the development of biosensors for medical applications, molecularly imprinted polymers (MIPs), electrochemistry, food quality and research fields combining chemistry and medicine in general. He has ca. 90 published papers (more than 1600 citations, h-index 22) and 4 patents; he has won several prizes including the Young Researcher in Electrochemistry attributed by the Portuguese Electrochemical Society. He is a member of the Portuguese Electrochemical Society (SPE), Portuguese Medical Association (Ordem dos Médicos), and Regional Medical Council of the São Paulo State (CREMESP).