

The Origins of the Ortho-, Meta-, and Para-Nomenclature

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Question

What is the origin of the prefixes ortho-, meta- and para- in both inorganic and organic chemical nomenclature?

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Answer

The prefix ortho- comes from the Greek *ortho-*, meaning “true or correct,” as in the word orthodox. The prefix meta- comes from the Greek *meta-*, meaning “following or after.” Thus the word metaphysics is a result of the coincidence that early editors of the works of Aristotle arranged his writings so that those dealing with speculative topics followed or came after those dealing with physics. Likewise, the prefix para- comes from the Greek *para-*, meaning “akin to or similar,” as in the word paraphrase.

The prefixes meta- and para- were both introduced into chemistry in the 1830s to describe closely related compounds, including various isomers, polymers, and compounds derived from one another via dehydration reactions. Thus in 1830 Berzelius suggested the name paratartrac acid for the racemic form of tartaric acid (1), and in 1833 Graham suggested the term metaphosphoric acid for HPO_3 (2). Within the context of the dualistic theory used at the time, acids were considered to be hydrates of the corresponding acidic oxides, and thus Graham viewed metaphosphoric acid as a monohydrate of P_2O_5 (i.e., $\text{P}_2\text{O}_5 \cdot \text{H}_2\text{O} \approx 2\text{HPO}_3$), derived via dehydration from the parent phosphoric acid, which he viewed as the trihydrate of P_2O_5 (i.e., $\text{P}_2\text{O}_5 \cdot 3\text{H}_2\text{O} \approx 2\text{H}_3\text{PO}_4$). In 1859 William Odling proposed the use of the prefix ortho- to designate the acid corresponding to the highest degree of hydration and applied the resulting ortho-meta nomenclature to the salts of various inorganic oxoacids, including both the silicates



Figure 1. Wilhelm Körner (1839-1925).

and the phosphates (3). Note that, within this context, the terms ortho- and meta- have a certain logic as the ortho compounds are viewed as the “true or original” compounds and the meta as those which “follow or result” from dehydration.

Application of all three prefixes to the various isomers of disubstituted benzene derivatives was first popularized in the period 1866-1874 by the German-Italian chemist, Wilhelm Körner (figure 1), in connection with his pioneering determination of the structures of these compounds using of the technique of derivative isomer counting (4). Given the rather vague meaning of these terms, it is apparent that, within this context, the specific identification of the term ortho with the 1,2 isomer, meta with the 1,3 isomer, and para with

the 1,4 isomer is essentially arbitrary, and indeed, Körner originally used the term ortho to designate the 1,4 isomer, the term meta to designate the 1,2 isomer and the term para to designate the 1,3 isomer. Failure of later chemists to heed Körner's original choices eventually led to our current equally arbitrary usage, which was first officially adopted by the Chemical Society of London in 1879 (5).

However, despite this apparently haphazard path, one can construct a semi-plausible justification for our current usage. One of the lesser meanings of para is "beside or along side of" and this could be construed as reflecting the fact that the para isomer is usually formed along with the ortho isomer as a by-product of an aromatic substitution reaction. Likewise, since meta can mean "beyond," it may be interpreted as meaning that formation of the 1,3 meta isomer involves moving one of the substituents one position beyond that found in the 1,2 ortho isomer. Unhappily, it is not known whether such linguistic considerations actually played a role in the revision of Körner's original choices.

The terms ortho and meta continue to be used in inorganic chemistry to describe oxoacids and oxosalts formally related via dehydration, though it is now known that significant differences in structure and degree of polymerization are also involved in these reactions (6). Likewise, usage of all three prefixes to indicate various isomers is now restricted almost totally to the disubstituted derivatives of benzene, though occasional residues of the older, looser, usage to indicate closely related compounds still persist, such as the terms paraformaldehyde and paraldehyde to indicate various polymers of formaldehyde and acetaldehyde.

Literature Cited

1. M. P. Crosland, *Historical Studies in the Language of Chemistry*, Harvard: Cambridge, 1962, p. 328. Crosland fails to provide an original reference for this assertion.
2. T. Graham, "Researches on the Arsenates, Phosphates and Modifications of Phosphoric Acid," *Phil. Trans. Roy. Soc.*, **1833**, 123, 253-284.
3. W. Odling, "On Ortho and Metasilicates," *Phil. Mag.*, **1859**, 18, 368-374.
4. All of Körner's papers on this subject have been collected together in W. Körner, *Über die Bestimmung des chemischen Ortes bei den aromatischen Substanzen (1866-1874)*, Klassiker der exakten Wissenschaften, No. 174, Engelmann: Leipzig, 1910.
5. Anon. "Instructions to Abstractors," *J. Chem. Soc.*, **1879**, 35, 276-281.
6. IUPAC, *Definitive Rules for Nomenclature of Inorganic Chemistry*, Butterworths: London, 1957, p. 46.

Do you have a question about the historical origins of a symbol, name, concept or experimental procedure used in your teaching? Address them to Dr. William B. Jensen, Oesper Collections in the History of Chemistry, Department of Chemistry, University of Cincinnati, Cincinnati, OH 45221-0172 or e-mail them to jensenwb@ucmail.uc.edu

2009 Update

Since writing this column I have discovered an earlier discussion of the history of this question in the privately printed book:

L. Dobbin, "Ortho, Meta, Para," in *Occasional Fragments of Chemical History*, Privately Printed: Edinburgh, 1942, pp. 45-63.

I have also discovered an earlier example of our current identification of ortho, meta, and para with the 1,2; 1,3, and 1,4 positions, respectively, in disubstituted benzene derivatives:

A. Ladenburg, *Theorie der aromatischen Verbindungen*, Vieweg: Braunschweig, 1876, p. 30.