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Commentary

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Why Teach Molality in General Chemistry?

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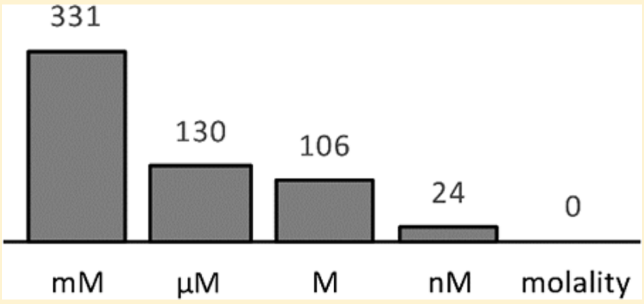
Supporting Information

ABSTRACT: We question the usefulness of presenting molality in general chemistry. This unit creates confusion and has little application beyond molar mass calculations based on freezing point depression. To investigate which concentration units research chemists use, we tallied the units used in a single issue of the *Journal of the American Chemical Society*. Molarity based units were used most frequently, with 591 usages. Molality did not appear. The academic community should reconsider having molality within the general chemistry curriculum.



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There have been many calls to reform the general chemistry curriculum.[1,2] It has been criticized for being too broad and not focused. It has been asked, "What should not be taught?"[2] Based on our experience and a study presented here, we suggest that molality is one answer.

MOLALITY IN THE CURRENT GENERAL CHEMISTRY CURRICULUM

Molality is a confusing unit. Does it consist of moles of solute per liter solution? Per kilogram solution? Per kilogram solvent? The close similarity between the definitions of molarity and molality—even their similar pronunciations—further exacerbates the confusion.

The extremely limited number of applications of molality within the general chemistry curriculum further diminishes its significance. Molality's only prominent role is linked with the colligative properties of matter. It is used as a component in the freezing point depression equation or the boiling point elevation equation, shown below,

$$\Delta T_{f,b} = imK_{f,b}$$

where ΔT_f is the change in freezing point (°C); ΔT_b, the change in boiling point (°C); i, the van't Hoff factor; m, molality (moles solute/kg solvent); K_f, the molal freezing point constant (°C/m); K_b, the molal boiling point constant. This relationship is used in a common laboratory exercise[3] wherein the students measure the freezing point depression in order to calculate the molar mass of a solute.

Molality can be effortlessly removed from these applications simply by replacing molality with the fundamental units, moles solute particles/kg solvent.[4] This substitution is recommended by the National Institute of Standards and Technology, NIST, which considers molality obsolete.[5]

Molality has a secondary application, routinely appearing in algorithmic conversion exercises. At their most challenging, the students are tasked with converting a molarity to molality or vice versa.

We argue that the only purpose of these algorithmic exercises is to familiarize students with molality. If molality is removed from the colligative property equations, the necessity of molarity to molality conversions is also removed.

Another compelling argument for removing molality from the general chemistry curriculum comes from the ACS Examination Institute. Their most recent Anchoring Concept Content Map for General Chemistry[6] does not contain molality.

INVESTIGATING PROFESSIONAL USE OF CONCENTRATION UNITS

In our experience, the only place we have ever encountered molality was general chemistry classes, always linked to colligative properties. We hypothesized that molality is not typically used by practicing chemists, and tested our hypothesis by tallying all the concentration units used in a single issue of a main-stream chemistry journal.

We selected the *Journal of the American Chemical Society* to be examined,[7] because it is a respected journal that features contributions from a broad array of chemistry subdisciplines. We examined a printed version of the first issue of the *Journal of the American Chemical Society* in 2015,[7] and we tallied each use of every concentration unit. The Supporting Information for this issue was not counted, nor were concentration derived measurements such as K_{eq}. Units that appeared multiple times in a graph, a table, or in a sentence were counted as one use. Parts per million used to indicate NMR data were not counted. Our results are shown in Figure 1.

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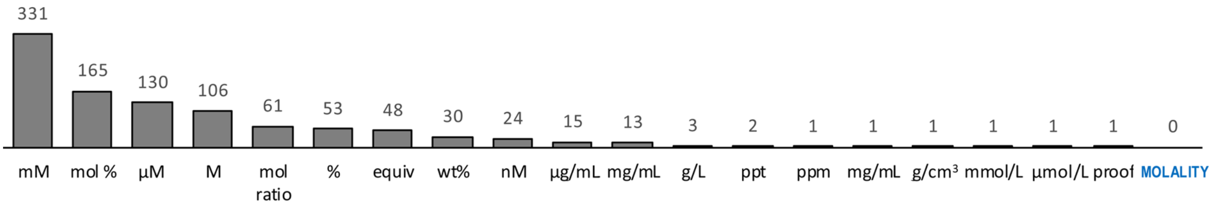

Figure 1. Occurrence of concentration units in the *Journal of the American Chemical Society* (Vol. 137, Issue 1, pp 1−550, Jan. 14, 2015). The definitions and abbreviations used in this graph are presented in the Supporting Information.

In this issue, molality was *never* used, whereas variants of molarity, such as nanomolar, were used 591 times. The percent (%) symbol, used by itself, represented three different concentration units, which were usually easily distinguished by the states of matter: %mass/mass (13 uses), %mass/volume (7 uses), or %volume/volume (33 uses).

We recognize that this survey is not exhaustive, and alternative procedures (such as electronic searches) could produce more precise counts. However, we do believe our results are indicative of the nonuse of molality outside of undergraduate education.

CONCLUSIONS

On the basis of our study, it appears that when publishing, chemists rarely use molality. If modern chemists do not use molality, why do we teach it? Is it needed for the freezing point depression experiments? No, because it can easily be replaced with the fundamental units, mole solute per kilograms solvent.

Eliminating the discussion of molality would free up time to introduce the frequently used variants of molarity such as milli-, micro-, or nanomolar. Or considering the overly full general chemistry curriculum, any number of existing topics could be addressed more thoroughly and meaningfully.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00497.

Table with definitions and abbreviations used in Figure 1 (PDF, DOCX)

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Notes

The authors declare no competing financial interest.

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