# Diagram Center report on Chemistry

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## Introduction

In the final year of the Diagram Center grant, we agreed to explore Chemistry notation in the standards arena. As a result, Benetech and DAISY reached out to leaders in the field of Chemistry and accessibility. A new “Chemistry for the Web and in Publishing” Community Group (CG) was formed at the W3C.

Find the home page at:

<https://www.w3.org/community/chem-web-pub/>

The description of the Community Group is: the "Chemistry for the Web and Publishing" Community Group will focus on moving beyond simply providing images of Chemistry content on the web and in published materials to a semantically rich form that will work for everybody, including persons with disabilities.

The chairs are:

George Kerscher, Benetech and DAISY Consortium, Dan Barrett, Houghton Mifflin Harcourt: Education and Learning Resources, And Cary Supalo, Educational Testing Service (ETS).

There are now 24 members of the Community group. See the full listing at:

<https://www.w3.org/community/chem-web-pub/participants>

## Work in the First Year

In the past year, monthly Zoom calls have been held, and the CG first discussed the full range of issues that should be addressed long term. The next issue was to identify the scope of work to be done this current year. The CG agreed that the most pressing issue was to work on Chemistry semantics expressed using MathML.

### Chemistry Semantics Expressed in MathML

The MathML Community Group in the W3C is moving to update MathML to version 4.0. In preparation for that move, the MathML CG was looking at issues they need to address. The semantics of Chemistry was one of the areas they identified. The formation of the Chemistry on the Web and in Publishing CG provided the perfect group collaboration environment.

First, MathML needed to be able to identify the expressions as being Chemistry, instead of Math or Physics. This was very straightforward.

Secondly, we want to be able to use Text-To-Speech (TTS) to speak the chemical expressions properly, and we want to be able to represent the information in braille as well. In most cases, a chemical symbol representation is unique, and with these instances there is no problem speaking the chemical element or providing a braille representation. However, there are many cases where a symbol may have more than one semantic representation. For example, in Physical Chemistry, “K” could be Kelvin or potassium, or in Organic and Inorganic chemistry “CO” could be carbon monoxide versus cobalt.

This is the area where the Chemistry on the Web and in Publishing CG had a great deal of work to do. All symbols that are semantically different, but use the same symbol had to be identified. The area of Chemistry also had to be noted, and if the symbol changed semantics when used in combination with other symbols. The CG also needed to note how the elements were spoken in normal conversation or in the classroom. If a symbol is a capital or lower case is significant, but it is tedious to say “cap” before each upper-case symbol.

The work of the CG helped the MathML group to develop a system to add the semantics to the encoding that eliminated ambiguities and enabled speech rules to be developed for the correct pronunciation of the chemical equations as they are spoken.

While excellent work has been delivered to the MathML group, it is expected that there will be ongoing work needed to evolve this development.

The recommendations that have been developed are publicly available at:

https://docs.google.com/spreadsheets/d/1h-8k\_bwQ1bO7gusb0O2DfcEs0DZUAo6QVGYZuVjWVB8/edit#gid=0

### Information Sharing in the Community Group

In addition to the MathML work on semantics, the Community Group was able to share information about developments worldwide in the area of accessible Chemistry. For example, the work of

Volker Sorge on presenting chemical formulae in an SVG graphic and highlighting and speaking information while the items are traversed was explored. This ground-breaking work can be found at:

<http://www.progressiveaccess.com/chemistry/index.php>

Another presentation worth noting is: “Proposed Applications of MathML to Chemistry Pedagogy”

By Stefan M. Kilyanek, Associate Professor (as of 8-20-2020), Department of Chemistry and Biochemistry, University of Arkansas

## Funding for Ongoing Work in the Community Group

The initial activity of the Chemistry for the Web and in Publishing Community Group has discovered that to make significant progress on making Chemistry accessible to students and professionals with disabilities will require serious funding. We have made excellent progress in the speaking and braille presentation of Chemistry in MathML, but this work needs to continue and be maintained.

Chemistry is one area of STEM that poses unique challenges. proper reading of Chemical equations and Chemical formulas is fundamental. There are many visual presentations of Molecular drawings and molecular structures, found in STEM materials at all levels of education that require access. More advanced Chemistry deals with Stoichiometry and Dimensional analysis

Several individuals have agreed to explore within their companies the possibility of writing grants to further the “research” for accessible Chemistry. Houghton Mifflin Harcourt, Educational Testing Service, and Pearson are now exploring possibilities. Benetech and DAISY have voiced interest in this research as well.

Some areas to consider:

* We could add Chemistry images to ImageShare
* We could develop standardized Chemistry descriptions in ImageShare; this is significant work to standardize the approach to spoken Chemistry. This also has far-reaching impact, because it can be used to guide developers of TTS software that reads chemical notation. This is significant effort and involves the large community.
* We can produce 3D models of chemical structures that are basic to education.
* Building on the ImageShare descriptions, we can produce “tours” or guides to feel and learn the 3D tactile models.

We have seen Proof of concept demonstrations of an SVG rendering of chemical formulas. This concept delivers the visual presentation coupled with correct spoken notation, along with the refreshable braille. This concept will require significant work to bring it to the point where it is embraced in educational and professional circles. This also has the potential to be a breakthrough in machine and human interactions.

## Conclusions

The Chemistry on the Web and in Publishing Community is established and working well. At the conclusion of the Diagram Center grant, no members will be funded to participate. It is expected that because of the commitment to the accessibility of Chemistry, the work will continue, but at a slow pace. We expect the pronunciation rules for Chemistry in MathML will progress and be established.

However, there is a great deal of significant work to do, and without specific funding, the work will not progress sufficiently to have a major impact on education and the field of Chemistry. We therefore encourage the writing of grants in this domain and encourage funding agencies to prioritize the funding of proposals in the domain of accessible Chemistry.