Using 3D Printing and Magnets to Model Chemical Reactions

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Introduction

- 3D Printing is emerging as a new medium for creating physical models for chemistry education [1,2]
- Through 3D printing came the creation of new interactive models that can be utilized by students in introductory chemistry courses.
- These molecules supplement existing teaching tools for difficult concepts that currently lack physical models.
- They are relatively easy to produce and have a positive impact on students perceptions of learning.

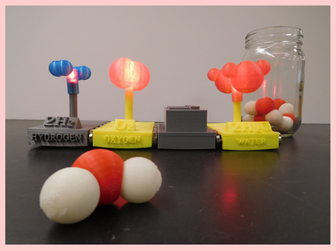
Design

- OpenScad was used to create our models codes that transfer as an STL file to any 3D printers program
- All models are printed designed and printed off in individual pieces
- Magnets are placed within grooves by superglue
- A weld is placed over the hydrogens grooves with a 3D printer pen

```
hull()
{
sphere(20);
translate([25,0,0]) sphere(12);
}

hull()
{
sphere(12);
translate([25,0,0]) sphere(20);
}
```

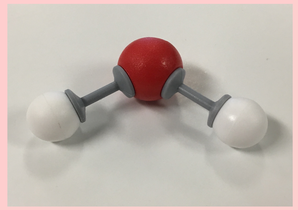
Sample OpenSCAD code



All models replicating reactions and equations

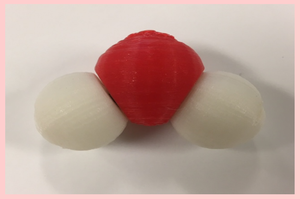
Reaction Models

- The models created included individual hydrogens and oxygens that bond to form water
- The atoms can be used to represent angles and bonding
- They can be placed in a jar in separate layers and shaken to represent a complete homogenous reaction
- Water molecules form within relative time to an actual reaction



Ball and stick water & molecule model &

Hydrogens and oxygens layered in jar &



3D printed water molecule &

Water molecules formed in jar

Oxygen &

Hydrogen with weld

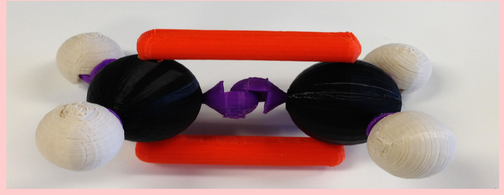
Hydrogen

Conclusions

- Utilizing 3D printing is a viable method to create models of chemistry concepts that don't currently exist
- Similar projects can be created by 3D printing due to the very little CAD experience needed
- Many fields could potentially benefit from 3D printing

Future Work

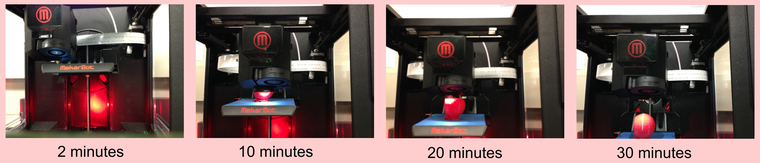
- 3D printing could also be used to create low-cost instrumentation for chemistry labs
  - &A colorimter was already made[3] with an electrochemical apparatus
  - &Models showing hybridization and the Bohr model have also been designed
- &Other fields outside of chemistry could benefit as well
  - Outreach programs that involve home-schooled high school students and with elementary aged students



Hybridization Model

3D Printing

- &3D printing allows for the rapid design and manufacture of prototypes at a relatively low cost
- &Depending on the size, a model can take ten minutes to two hours to be completely printed
- &This process works by heating thin plastic to 230°C and extruding by the directions from the computer code
- &There are many different types of 3D printers and they can vary in cost, but once the initial costs are paid, the costs of printing is relatively low

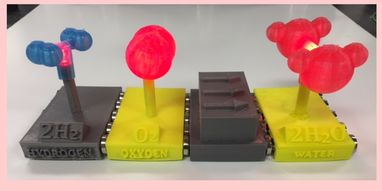


2 minutes | 10 minutes | 20 minutes | 30 minutes

A 3D printer making a model of an atom over the course of 30 minutes

Equation Models

- Balancing chemical equations is hard!
- Developed a series of models to help students learn &
- When the correct equation is formed and balanced it will produce a light response &
- Gives immediate response to students



Chemical equation that forms two water molecules

Individual molecule of Carbon Dioxide

Wires located under bottom of molecules

Selected References

1. Scalfani, V. F.; Vaid, T. P., 3D Printed Molecules and Extended Solid Models for Teaching Symmetry and Point Groups. *Journal of Chemical Education* ***2014, 91 (8), 1174-1180.***
2. Blauch, D. N.; Carroll, F. A., 3D Printers Can Provide an Added Dimension for Teaching Structure–Energy Relationships. *Journal of Chemical Education* ***2014, 91 (8), 1254-1256.***
3. Mendez, J. D., An Inexpensive 3D Printed Colorimeter. *The Chemical Educator* (***2015, 20, 224-226.***
4. Smiar, Karen, Mendez, J.D., Creating and Using Interactive, 3-D Printed Models to Improve Student Comprehension of the Bohr Model of the Atom, Bond Polarity, and Hybridization. *Journal of Chemistry Education* ***2016, 93 (9), 1591-1594.***

Acknowledgements

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