UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Creating and Recording Demonstration Experiments in Chemistry

Title

Thomas Junk, Ryan L. Simon and Tolga Karsili

Name of Submitter
(Faculty or Staff Only)

UL Department of Chemistry

Organization

Title: Professor/Head Date: 7/8/2021
Name (Contact Person): Thomas Junk
Address: Department of Chemistry, P.O. Box 44270, University of Louisiana at Lafayette, 70504
Phone Number: 337-482-6735 Email: txj9137@louisiana.edu
Department/College/Org: Department of Chemistry

ABSTRACT (250 words or less):

One of STEP's objectives is the creation, deployment, and maintenance of effective learning environments that facilitate multiple instructional and learning styles. It is important to make lectures interactive and exciting. Chemistry is an applied science and demonstration experiments are central to chemical education. In the past, chemistry faculty relied on videos downloaded from YouTube when available, but often their quality, availability and content left much to be desired. Materials for ten lecture demonstrations are requested so that they can be offered to students on a regular basis, at special campus events such as Chemistry Week, and also recorded for online delivery. All demonstrations are visually striking, readily implemented, and offer a high degree of safety for students and faculty alike. The budgeted items have minimum life expectancy of eight years. It is anticipated that the majority of students enrolled general chemistry, organic chemistry and physical chemistry will be captivated more by in-house demonstrations carried out with participation of their peers than by often grainy YouTube videos, at a very modest overall project cost.

3a. Purpose of grant and impact to student body as a whole

The proposed project will replace third party videos of experiments with actual live demonstrations that will be performed with student participation and recorded for a wider audience. We request one time funding to create demonstrations suitable for deployment in general chemistry, organic chemistry and physical chemistry. Each experiment is both visually striking and highly educational. It allows students to participate and represents a key step in making chemistry more applied and interactive. A data base of demonstration experiments recorded at UL will replace often low quality YouTube videos that are "borrowed" from outer institutions, featuring their facilities and their faculty. The hardware and software necessary for recording and editing is available at our department.

Experiment 1, superabsorbent polymers (general chemistry): the instructor mixes polyvinyl alcohol and sodium polyacrylate with water. The superabsorbent polymers bind up to 400x their volume in water, resulting in a thick gel forming for polyvinyl alcohol and a drastic volume increase for sodium polyacrylate. This experiment relates chemical principles and daily applications at an early stage. This effect is striking, generating a huge amount of solid material seemingly out of nowhere.

Experiment 2, magnetism, electrostatic forces, the plasma state (general chemistry): general chemistry heavily relies on basic physical principles, which are not always fully embraced by chemistry students or science students in general. A cube with iron filings, a spinning ferrofluid display and a magnetic field chamber will be used to visualize magnetic fields. With the help of a small portable Van de Graaff generator and a Tesla coil, the instructor demonstrates basic principles needed as students master basic concepts such as the structure of matter, chemical charges and aggregate states of matter. A particularly striking example, in which the operator activates a gas discharge lamp held in his hand without connecting it to a power outlet or being electrocuted, will be shown and recorded.

Experiment 3, electrolysis, proportionality law (general chemistry): A portable Hoffman electrolysis cell will be used to introduce basic principles of electrochemistry and the law of constant ratios. In contrast to more complex electrolytic devices this one is fully transparent so students can easily observe what is happening.

Experiment 4, sulfur hexafluoride, a hypervalent gas (general chemistry, inorganic chemistry): the concepts of the octet rule and its limitations will be accompanied by several stunning experiments performed with sulfur hexafluoride, a highly inert, non-toxic and extremely dense hypervalent gas. The "boat experiment" floats an aluminum boat on an invisible lake of sulfur hexafluoride gas. The instructor will inhale a small quantity of sulfur hexafluoride, which will drastically lower the pitch of his voice (the opposite to the well-known effect for helium, which raises the pitch of the human voice).

Experiment 5, making nylon (organic chemistry): the principle of step polymerization will be illustrated by making nylon from sebacyl chloride and 1,6-hexanediamine. The instructor layers solutions of both precursors into a beaker, then pulls a nylon string out of it. The nylon is continuously re-formed as it is being removed, giving the impression of an endless nylon rope being formed. Different dyes can be added for striking visual effects.

Experiment 6, radical protobromination (organic chemistry): the concept of radical reactions and photochemistry will be illustrated by exposing a pre-prepared solution of bromine (available here) in isooctane to light by placing it next to an ultraviolet light source. Students can observe the resulting photoreaction. Currently, no videos of radical reactions can be found online.

Experiment 7, optical activity (organic chemistry): a beaker filled with corn syrup is placed on a projector. Polarization filters are placed above and below the beaker, then one is rotated. The color of the corn syrup seems to change because its optical activity causes it to rotate polarized light at different angles for different wavelengths.

Experiment 8, high temperature superconductivity (general chemistry, physical chemistry): students will get an opportunity to see a high temperature superconductor first-hand: a magnet will be levitated above a superconductive disc, chilled with liquid nitrogen. The Meissner effect will be demonstrated. Currently, the concept of superconductivity is presented to students in a purely abstract way.

Experiment 9, the Sterling engine (physical chemistry): the principles of heat engines, open vs. closed systems and the Carnot cycle will be enhanced by showing students a miniature, but fully functional model of a Sterling engine in operation, which does not use any working fluids. This type of engine finds increasing application in the "green", environmentally sound conversion of solar energy to electricity. The concept of a heat engine using a gas as an operating medium is much more accessible to students when demonstrated by example.

Experiment 10, liquefying atmospheric oxygen and methane (general chemistry, physical chemistry): Using liquid nitrogen, atmospheric oxygen will be condensed due to the fact that it has a higher boiling point than nitrogen. A flame test will demonstrate that the collected liquid is indeed oxygen. Then, natural gas (available throughout the building) will be liquefied and its identity as methane will be demonstrated based on its boiling point. This experiment demonstrates the changes in the strength of London-Dispersion interactions and how such changes affect the boiling point.

Currently, approx. 1,600 students are enrolled in general chemistry lectures each year, 500 students in organic chemistry lecture and 90 students in physical chemistry lectures. Notably, general chemistry lectures are sometimes described as "dry", lacking components to arouse student interest. All three proposal authors have shown lecture experiments in the past, but the design of our lecture halls precludes the use of many chemicals. As a result, the use of demonstration experiments, either live or pre-recorded, was severely curtailed. This proposal aims to offer updated experiments that can be performed safely, yet are captivating and relate to the topics covered in our lectures. The authors pledge to show these demonstrations in their own lectures and will work with colleagues to make the covered material more appealing by relating it to first-hand student observations. Overall, a majority of all students enrolled in chemistry lectures is expected to benefit.

3b. Projected lifetime of enhancement

A one-time shipment of liquid nitrogen ($20) will be used for initial testing and training (experiments 8 and 10). All other materials are expected to last at least 8 years. Sulfur hexafluoride is expected to suffice for 8-10 years. The remaining items will last for at least 15-20 years.

3c. Person(s) responsible for:

i. Implementation

Drs. Junk and Simon will implement organic chemistry experiments. Drs. Simon and Karsili will jointly prepare ready-to-go experiment kits for general chemistry. Dr. Karsili will implement and record physical chemistry experiments. Dr. Simon, who specializes in educational chemistry, will edit/comment the videos.

ii. Installation

There is no installation, all items are easily moved to and from lecture halls.

iii. Maintenance

Normally, no maintenance is required. Replacement parts will be ordered by the Department and installed by Dr. Simon, should this become necessary.

iv. Operation

The experiments will be carried out by instructors assigned to chemistry lectures. I addition, Dr. Simon will train several highly motivated chemistry seniors to participate in them.

v. Training (with qualifications)

Dr. Simon specializes in chemical education and will supervise training in the proper performance recording of demonstration experiments.

Budget Proposal

1.	**Equipment**	**$**	**0.00**
2.	**Software**	**$**	**0.00**
3.	**Supplies**	**$**	**2,275.46**
4.	**Maintenance**	**$**	**0.00**
5.	**Personnel**	**$**	**0.00**
6.	**Other**	**$**	**10.90 (shipping)**
TOTAL:		**$**	**2,285.46**

d. Budget Narrative:
Supplies: A detailed list of all items requested for each experiment is provided below. A one-time purchase of liquid nitrogen is included for initial experiment testing and training. After this, any additional liquid nitrogen will be provided by the Department as needed.

Experiment	Item		Cost		Shipping cost
1	Polyvinyl alcohol, 500g	$	79.60	$	-
1	Sodium Polyacrylate, 5lb	$	116.94	$	-
2	Tesla coil demonstration experiment	$	187.99	$	-
2	Van De Graff Generator	$	323.95	$	-
2	Globe with iron filings and fluid	$	49.95	$	-
2	Spinning ferrofluid display	$	99.99	$	-
2	Basic magnetic field chamber	$	29.27	$	-
3	Electrolysis demonstration apparatus	$	130.19	$	-
4	Sulfur hexafluoride, 17lb	$	930.20	$	-
5	Sebacyl chloride, 100 g	$	87.14	$	-
5	1,6-Hexanediamine, 100g	$	25.36	$	-
6	2,2,4-Trimethylpentane, 500mL	$	44.89	$	-
7	2 Polarization filters, 6x6''	$	21.00	$	-
8	Superconductivity demonstration kit	$	79.00	$	10.90
9	Sterling engine model	$	49.99	$	-
10	Liquid nitrogen, 40L	$	20.00		
	Total	**$**	**2,275.46**	**$**	**10.90**

Previous funded STEP projects

Thomas Junk has previously authored the following funded STEP proposals:

- Smart Classrooms in Chemistry, T. Junk and A. Gallo, $30,000, Awarded 2012.
- Laptop Computers for Chemistry Lectures, T. Junk, $3,285, Awarded 2013.
- Raman Spectroscopy in Chemistry Labs, T. Junk, $10,655, Awarded 2015.
- Purchase of an Attenuated Total Reflectance (ATR) Tool for Chemistry to Conduct Infrared Spectroscopy on Solids, T. Junk and A. Gallo, $5,602.50, Awarded 2016.
- ChemDraw Chemical Structure Drawing Software for Student Use and Training, T. Junk, $4,460, Awarded 2017.
- Chemical Reactions with Light: UV Lamps for Photochemical Experiments in Organic Chemistry Labs, T. Junk and R. Simon, $2,100.00, awarded January 2018.
- Purchase of an Infrared Spectrometer for Chemistry, T. Junk and R. Simon, $23,595.20, awarded December 2019.

Ryan Simon has previously authored the following funded STEP proposals:

- Organic Chemistry Laboratory Equipment Grant, R. Simon and A. Gallo, $3666.50, awarded in May 2016.
- Demonstration Equipment Grant, R. Simon, $501.64, awarded in January 2017.
- Maker Lab for Montgomery Hall, R. Simon and Y. Wang, $3649.79, awarded in May 2017.
- Whiteboards for Montgomery Hall, R. Simon, $6371.96, awarded January 2018.
- Chemical Reactions with Light: UV Lamps for Photochemical Experiments in Organic Chemistry Labs, T. Junk and R. Simon, $2100.00, awarded January 2018.
- Electric Thermometers Grant Proposal, R. Simon and A. Gallo, $1850.00, awarded May 2018.
- Chemical Reactions with Light: UV Lamps for Photochemical Experiments in Organic Chemistry Labs, T. Junk and R. Simon, $2,100.00, awarded January 2018.
- Purchase of an Infrared Spectrometer for Chemistry, T. Junk and R. Simon, $23,595.20, awarded December 2019.

Tolga Karsili has **not** previously authored any STEP proposals.