Rec 2/16/18

MTSU Clean Energy Initiative Project Funding Request

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There are five (5) sections of the request to complete before submitting. See http://www.mtsu.edu/sga/cleanenergy.shtml for funding guidelines. Save completed form and email to cee@mtsu.edu or mail to MTSU Box 57.

1. General Information	
Name of Person Submitting Request **Ngee Sing Chong**	
Department/Office **Chemistry/SCI 3067**	Phone # (Office) **898-5487**
MTSU Box # **Box 68, MTSU**	Phone # (Cell) **615-556-5509**
E-mail **nchong@mtsu.edu**	Submittal Date **February 16, 2018**

2. Project Categories (Select One)			
Select the category that best describes the project.			
X	Energy Conservation/Efficiency	**X**	Sustainable Design
	Alternative Fuels		Other
	Renewable Energy		

3. Project Information
a. Please provide a brief descriptive title for the project. **b.** The project cost estimate is the expected cost of the project to be considered by the committee for approval, which may differ from the total project cost in the case of matching funding opportunities. **Any funding request is a 'not-to-exceed' amount. Any proposed expenditure above the requested amount will require a resubmission.** c. List the source of project cost estimates. d. Provide a brief explanation in response to question regarding previous funding.
3a. Project Title **Purchase of Ultrasonic-Microwave Extractor to Enhance Student Laboratory Experience in Chemistry Courses**
3b. Project Cost Estimate **Total Amount Requested=$11,165.00** **Ultrasonic-Microwave Extractor price plus costs of shipping and 110V/220V electrical outlet adapter.**
3c. Source of Estimate **Vendor's price quote from Tryte extractor is attached.**

3d. If previous funding from this source was awarded, explain how this request differs?

The previous funding in Fall 2014 was for the purchase of a hydrogenation reactor intended to eliminate the use of hydrogen cylinder as a reactant source so that lab environment is safer without the high pressure cylinders of hydrogen gas which is explosive if it is leaked and accumulated to a high level. Another funded project in Fall 2017 is for the modification of ICP-OES and GC instruments donated by Tennessee Health Department. In this proposal, an ultrasonic-microwave reactor will be used for student research or class experiments in order to (i) reduce energy usage, (ii) shorten reaction time, (iii) increase the yields of reaction products by following the principle of sustainable synthesis, and (iv) improve safety by eliminating the traditional heating mantles or Bunsen flame burners.

4. Project Description

(Completed in as much detail as possible.)

a. The scope of the work to be accomplished is a detailed description of project activities.
b. The benefit statement describes the advantages of the project as relates to the selected project category.
c. The location of the project includes the name of the building, department, and/or specific location of where the project will be conducted on campus.
d. List any departments you anticipate to be involved. Were any departments consulted in preparation of this request? Who? A listing may be attached to this form when submitted.
e. Provide specific information on anticipated student involvement or benefit.
f. Provide information for anticipated future operating and/or maintenance requirements occurring as a result of the proposed project.
g. Provide any additional comments or information that may be pertinent to approval of the project funding request.

4a. Scope: Work to be accomplished

The ultrasonic-microwave extractor system include the three operating modes of ultrasonic, microwave, and cooperative control for performing chemical extraction and synthesis reactions for analytical and organic chemistry laboratory experiments. The installation and evaluation of the equipment will be carried out at different temperatures for different durations and compared to similar process using conventional hot plates and heating mantles. Their extraction and reaction efficiencies are compared to determine energy savings and the reduction in sample preparation time for students. The extractor will be set up for student use in SCI 3070 and its small size allows it to be moved to other laboratories if necessary. Faculty sponsors will determine which courses the equipment will be used for.

4b. Scope: Benefit Statement

With the new microwave system, chemistry students will no longer heat flasks in the lab using older, less efficient methods such as heating mantles or Bunsen burners. Instead they will insert extraction or reaction vessels into the ultrasonic-microwave equipment. The heat generated by the instrument will produce chemical reactions much quicker than before, with the added benefit of minimizing the production of byproducts and chemical waste. Students will also learn about modern microwave syntheses and will be better prepared in using the emerging microwave reactor technology that is being adopted by industry and the academia. The new microwave synthesis system is based on green chemical principles that include waste prevention, use of methods to minimize toxicity, using safer solvents, energy efficiency, and preventing accidents.

4. Project Description (continued)

4c. Location of Project (Building, etc.)

MTSU Department of Chemistry (Science Building Room 3070 and 3107)

4d. Participants and Roles

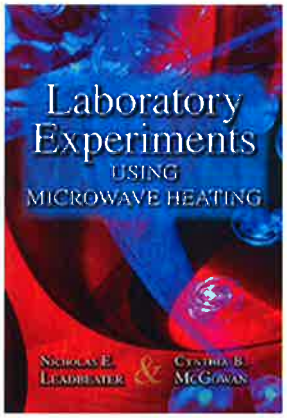
Ngee Sing Chong – Purchase and installation of the ultrasonic- microwave reactor; using microwave reactor in teaching and research; evaluating energy savings by switching from heating mantles and Bunsen burners to the microwave reactor.

Jessie Weatherly – Maintenance of the microwave reactor by periodic replacement of consumable parts.

Other Chemistry Faculty and Students – Use the reactors and record usage duration to help track the cost or energy savings compared to traditional heating methods.

4e. Student participation and/or student benefit

Students will be the main beneficiaries of the microwave reactor because they will learn a modern laboratory technique for synthetic reactions that will enable some of them to adapt to the modern industrial laboratory practice of using microwave reactors rather than traditional heating methods. Students will be able to follow existing microwave based chemistry experiments such as those described in the following lab manual.



Laboratory Experiments
Using Microwave Heating
Nicholas E. Leadbeater & Cynthia B. McGowan
CRC Press 2013

Presents 22 modern experiments for the chemistry lab

- Cycloaddition reactions
- Esterification reactions
- Condensation reactions
- Rearrangements
- Metal-catalyzed couplings, metathesis, click chemistry, cyanation
- Coordination chemistry
- Determination of empirical formula
- Extraction of essential oils
- Digestion and analysis by atomic absorption

4f. Future Operating and/or Maintenance Requirements

The ultrasonic-microwave reactor has few consumable parts other than the glassware, which can be purchased using funds from Chemistry Department. Jessie Weatherly, the Instrument Support Engineer in the Department of Chemistry, is in charge of maintenance for all laboratory equipment and will be able to take care of the maintenance and repair of the microwave reactor if the need arises.

4g. Additional Comments: **A similar proposal was submitted for campus fee funding in spring 2018 semester and was declined. The reason for the proposal not being funded could be due to the requested amount of $21,590.50 being greater than the funding limits. Therefore, I have searched multiple websites for the suppliers of extraction equipment that was more cost-effective. The current request of $11,165.00 was significantly less than the previous request and the extractor is still capable of delivering the necessary laboratory performance with energy and time savings.**

4g/ Information Pertinent to the Proposed Project

1. **Efficiency and Selectivity of Microwave Reactors in Organic Chemistry;**
   http://www.chem.tamu.edu/rgroup/djd/chem483/Projects/Microwave%20Chemistry.pdf

2. **Greening the organic chemistry laboratory: a comparison of microwave-assisted and classical nucleophilic aromatic substitution reactions**
   http://www.tandfonline.com/doi/pdf/10.1080/17518253.2015.1065010

3. **A critical assessment of the greenness and energy efficiency of microwave-assisted organic synthesis**
   http://140.123.79.90/~mash1225/images/microwave%20reference/c0gc00823k.pdf

4. **Microwave Chemistry—Out of The Lab and into Production**
   http://ctechinnovation.com/papers/Microwave-chemistry-out-of-lab-into-production.pdf

5. Project Performance Information

Provide information if applicable.

a. Provide information on estimated annual energy savings stated in units such as kW, kWh, Btu, gallons, etc.
b. Provide information on estimated annual energy cost savings in monetary terms.
c. Provide information on any annual operating or other cost savings in monetary terms. Be specific.
d. Provide information about any matching or supplementary funding opportunities that are available. Identify all sources and explain.

5a. Estimated Annual Energy Savings (Estimated in kW, kWh, Btu, etc.)

The energy savings vary greatly among different reaction conditions and should be evaluated on a case-by-case basis as pointed out in Reference 1 above. The comparison of the energy efficiencies of selected chemical reactions carried out using the microwave reactor and traditional thermal heating as described in Reference 3. The comparison and analysis of data are shown in the two tables below where (MW) refers to microwave-assisted reactions.

Table 1. Summary of results comparing microwave heating to conventional heating

Reaction	Time	Temperature	Yield
Suzuki coupling	2 h	120°C	92%
	2 min (MW)	160°C	99%
	1 min (MW)	155°C	98%
Dihydropyrimidine	8 h	120°C	35%
	4 min (MW)	145°C	71%
Ionic liquid	4 h	130°C	95%
	1 min (MW)	200°C	95%

Table 2. Comparison of energy use in microwave reactor and batch reactor

Reaction	Energy/kg in MW	Energy efficiency	Energy/kg in batch (Croda)	% energy saving in MW
Suzuki	0.381 kWh/kg	57%	3.60 kWh/kg	89%
Cyclisation	3.84 kWh/kg	42%	3.60 kWh/kg	–
Ionic liquid	0.382 kWh/kg	39%	3.60 kWh/kg	89%

5b. Annual Energy COST Savings ($)

The savings in energy expenditure is 89% but the actual energy cost savings will depend on actual reaction conditions.

5c. Annual Operating or Other Cost Savings. Specify. ($) **Please note the dependence of cost savings on reaction conditions and specific reactions or extractions described in 5b.**
5d.Matching or Supplementary Funding (Identify and Explain) **Department of Chemistry will provide supplementary funds of about $1,400 per year for the purchase of additional glassware and consumables needed for the using the ultrasonic-microwave extractor. Additional matching funds from MTSU Graduate Studies will be sought if necessary.**

Tryte Technologies

TRYTE TECHNOLOGY (H.K.) LIMITED
UNIT 04,7/F BRIGHT WAY TOWER NO.33 MONGKOK ROAD,KOWLOON, HONG KONG
Phone: 00852-23892981/0086-734-8770418
Cell: 0086-18173445727 or 0086-18007322239
Email: info@trytetc.com, Site: www.trytetc.com

PRICE LIST

Date	Valid date	Delivery	CURRENCY
2017.04.09	2017.07.30	Ex-works Hong Kong	USD$0.0

No	Order ID	Product Name	Unit Price(USD)	Qty	Total Price
1	TC-ER-02	Ultrasonic-microwave Cooperative Extractor/Reactor	$10,165	1	$10,165
Ex-works Hong Kong					

1、Ultrasonic-microwave Cooperative Extractor/Reactor

Capability Feature:

A multiuse instrument: three action modes including ultrasonic, microwave and cooperative mode are provided in a real multi-use instrument; best choice for the methods and mechanism research of chemical reaction, chemical synthesis, material preparation, chemical sample pretreatment, etc

Efficient ultrasonic oscillations: ultrasonic oscillations energy directly act on sample reactor, high acoustic vibration efficiency, low energy consumption, low noise; design of acoustic vibration and wireless, more convenient to put in and take out sample reactor.

A large treatment capacity: up to 500mL, greatly increase analysis sensitivity; meanwhile, reactor of different shape and volume can be made according to user's needs;

Operation is intuitionistic and convenient: microwave power and action time are adjustable, ultrasonic and microwave action mode and its degree may combine and set freely. Reaction condition and temperature are real-time monitored;

Multiple power control mode: time control, temperature control and firm power control make it possible for the operator to choose according to different sample system, analysis task and reaction type; Condition of low temperature and normal pressure: reduces the destruction of the sample's organic structure;

Safe and reliable: condition of low temperature and normal pressure, no need to process or buy reactor made by special material, the operation will be safer. Direct ultrasonic vibration has a higher efficiency and lower noise. Microwave leakage is less than 0.3mW/cm2 (national standard is 5 mW/cm2);

Wide application: widely used in sample pretreatment of organic, inorganic and biology analysis. Especially as a new reactor, it can widely used in university or scientific research unit for them to carry out many significative research operations about chemical reaction, organic synthesis, sample digestion or extraction;

Unique patent technology: 3 patent technology is used for the instrument (ZL 2004 2 0114391.1; ZL 2004 2 0014392.6; ZL 2004 0114393.0)

Software Interface

Technical Parameter:

A multiuse instrument: 3 different modes of action include direct ultrasonic, opening microwave and cooperative mode

Microwave power: 10-800W (adjustable); microwave frequency: 2450MHz

Ultrasonic power/ frequency: 50W/40KHz

Microwave action mode: nonburst continuous microwave heating

Ultrasonic action mode: small power ultrasonic transducer directly connect to reactor, low noise, acoustic vibration (energy) efficiency close to 100%

Microwave power control mode: time control, temperature control and constant power control

Temperature control: non-contact infrared temperature measurement, in the range of room temperature to 120ºC(±1ºC).

Program control: 9 programs can be set. Each program can be set 9 steps, each step may preinstall parameters such as time (1-999s), microwave power, working temperature, action mode control and ultrasonic (on/off).All the parameters are saved by computer, set, modified and called when needed.

Reactor monitor: real-time video monitor sample reaction state by 4" LCD

Reactor volume: 100mL, 250mL, 500mL (reactor of special specification can be made according to user's needs)

Power source: 220V±10%, 50Hz

Input power: 1360W

Furnace chamber volume: 27L

Exterior size: 430mm×512mm×510mm

Weight: 25Kg

Product Package: