Cross research lab and student research projects

The Cross lab in the Tokyo Tech School of Environment and Society, Transdisciplinary Science and Engineering department does research in several research areas: Biochemicals (Biochem), Energy policy and /Edtech to contribute to a sustainable global society. In addition, Asst. Prof. Cheng Shuo is undertaking research on uptake and effects of Microfibers on Freshwater Indoor Microcosm Systems and leads the Environmental Toxicology Research activity. Dr. Sasipa Boonyubol, a speically appointed Assoc. Prof. (lecturer), has research interests on biofuel processing, biomass conversion&upgrading, and education technology. The lab collaborates with Assoc. Prof. Tatsuya Wakeyama on energy policy research. Typical lab seminar photo below (pre-COVID).

Currently, there are 12 doctoral(D), master(M) and 4th year undergraduate students (B4) and periodically exchange students conducting research. The lab is very diverse with students from numerous countries (Bangladesh, Canada, Cambodia, China, India, Malaysia, Mexico, Philippines, Pakistan and USA). There are full-time graduate students, working-adult doctoral students, volunteers, and staff doing research. Students receive financial support from various scholarships and some are self-financed. Student's academic backgrounds are varied as well with prior degrees in Chemical Engineering, Environmental Engineering, Engineering Science, Computer Science, Materials Science, Educational Technology, Teaching English as a Foreign Language and Literature (liberal arts). Students attend weekly seminars to present research published papers or research progress reports. Education in the lab is very interdisciplinary, which is very unique at Tokyo Tech due to students' various educational backgrounds and research interests. Below is a photo from a laboratory seminar pre-COVID-19. Seven of the UN's SDG's are researched in the lab related to energy, education, environment, industrial support, infrastructure, clean water, and life underwater.

In addition, Prof. Cross manages the Tokyo Tech online education development office and conducts research on learning analytics. He also participates in various international research exchange programs, the Super Smart Society doctoral program, and Sustainable Social Infrastructure. Please contact Prof. Cross by email or via the lab homepage contact form for further information.

Jeffrey S. Cross cross.j.aa [at] m.titech.ac.jp
https://www.clab-tokyotech.org/

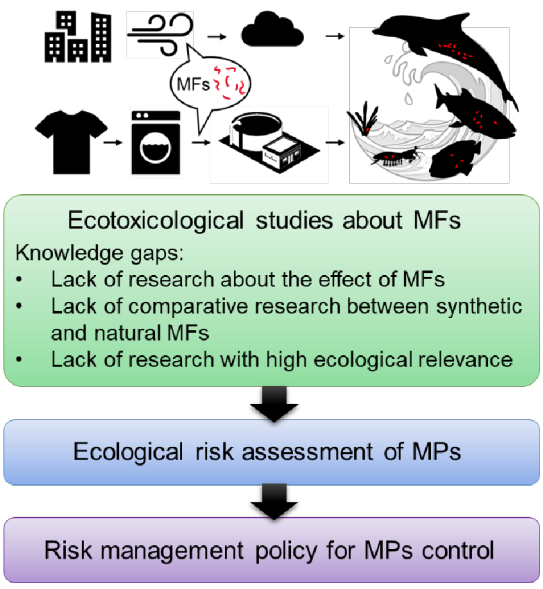
Environmental Toxicology Group:
Uptake and Effects of Microfibers on Freshwater Indoor Microcosm System

Shuo Cheng (Tei), D. Engr. Asst. Prof.

マイクロ繊維の取り込みと淡水コズム生態系への影響

Abstract

Microplastics (MPs) in the water body are novel pollutants that attracted attention in the scientific community in recent years. Microfibers (MFs), as one of the most common MPs, distribute highly overlaps with the dense population areas and pose a threat to biota, especially to humans. There are still several knowledge gaps on MFs so far, such as the lack of comparative studies with natural fibers or ecotoxicological data above the organism level, making it hardly possible to make a conclusive assessment ecological risk for MP up to now. This research proposes to conduct synthetic and natural MFs exposure experiments in a freshwater indoor microcosm with a three-species food chain. We will evaluate the effects of MFs on the microcosm from molecular to community level. The results can provide the necessary data for ecological risk assessment and help raise public risk perception of MFs. Eventually, contribute to the formulation of risk management policies for MPs.



Methodology

This research proposes to conduct synthetic, plant, and mineral MFs exposure experiments in a freshwater indoor microcosmic system with three trophic levels of the food chain (producer, first-level consumer, and second-level consumer). The stress response and adaptation of three model species on introduced MFs will be evaluated from molecule to community level under controlled biotic and abiotic conditions. Combining multivariate and statistical analysis methods, qualitative and quantitative analysis of the comprehensive effect of different materials and different concentrations of MFs on the microcosm will be carried out. We want to figure out:

a. Does MFs provide special effects on the biota due to their fibrous shape?

b. Compared with the natural MFs, what is the difference in the effects of synthetic MFs on the biota?

c. To obtain data with higher ecological relevance than previous studies that on each species separately.

(continued on next page)

It is possible to build a bridge between the laboratory and the ecosystem, which helps confirm extrapolations from laboratory data to the environment. The research results can provide the necessary information and data for the ecological risk assessment of MFs in the water body. It will help raise public risk perception to MFs, which has so far been neglected. Eventually, contribute to the formulation of risk management policies for MPs.

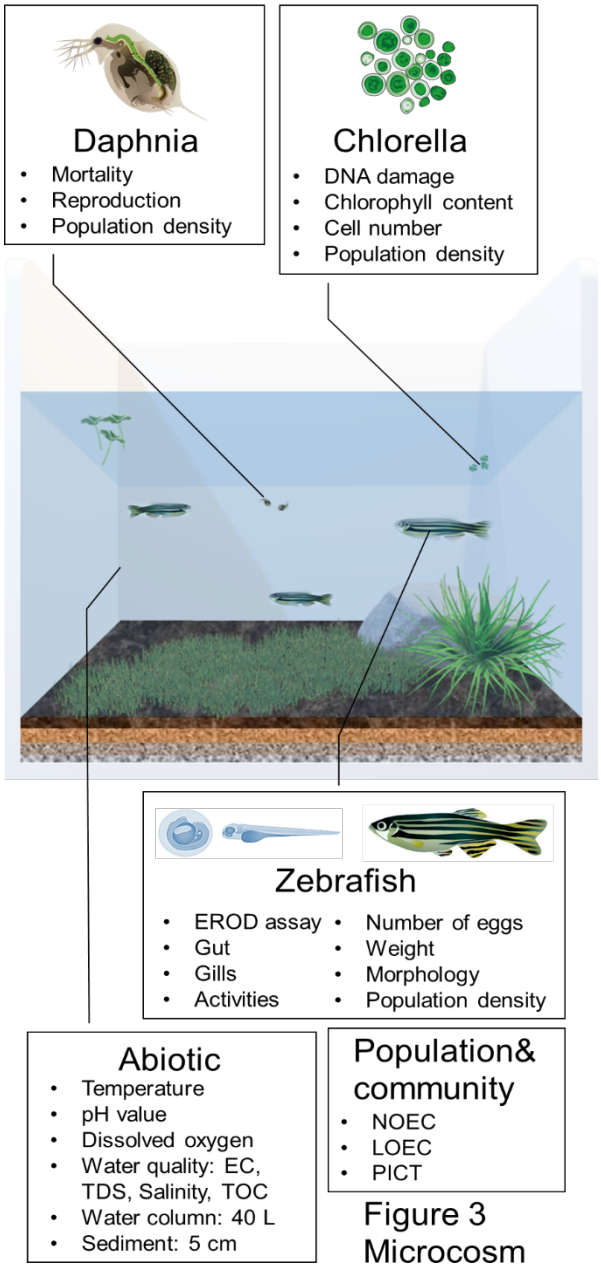


Figure 3 Microcosm

If you are interested in these topics please contact Asst. Prof. Cheng for further information and if interested apply for admission in order to join us!

Valorization of spent coffee ground as a bio-based composite phase change material

Sasipa Boonyubol, D.Engr, Assoc. Prof./ GSEP Lecture

With the climate change and the problem of global warming, the demand of energy is expected to increase worldwide along with the gradual rising of temperature. One of the approaches to solve the energy problem is finding the way to store and conserve the energy. If the thermal energy storage can be improved, the energy demand is expected to become lower. A phase change material (PCM) is a material that can store and release heat as the material changes its phase. The PCM can be applied in various types of application including food industry, building industry, automobile sector, or even in aerospace application, depending on the phase transition temperature range of the PCM. Some bio-materials have been selected to be used as the supporting materials for PCM. While the materials that is usable is limited, the solid residue from coffee seems to be an interesting and renewable choice.

Coffee is one of the most consumed beverages worldwide. After the brewing process, the solid residue is obtained in which it is normally called as the spent coffee ground (SCG). The question arises, where does the SCG go? It is often discarded on landfill which not only requires the waste management plan but also causes environmental problems due to its large amount generated annually around the world. In fact, SCG still contain various valuable substances which can be extracted for the further use in food industry and also be used as a feedstock to produce biofuel. Some commercial products made from SCG have also been sold, such as, coffee compact fire log, reusable coffee cup, coffee sunglasses, or even coffee sneakers!

In this research, the valorization of both SCG and SCG biochar to be a bio-based composite PCM will be studied. The SCG biochar will be collected after the pyrolysis. The SCG/SCG biochar will go through the impregnation process with natural wax to produce a bio-based composite PCM. Some challenges with bio-based composite PCM include the incomplete impregnation of wax into SCG, wax leakage problem, and low thermal conductivity. In this study, the combination of ultrasonication and vacuum impregnation is proposed to solve the problems mentioned earlier. The expected outcome is the production of a bio-based composite material from SCG that would be environmentally friendly and fully biodegradable that can be utilized in the industry.

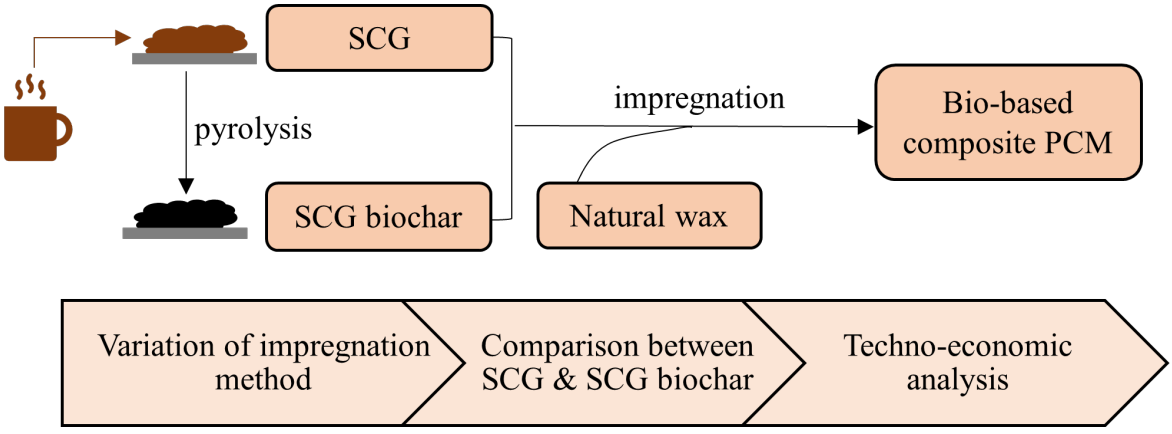


Fig. Overall process of proposed research

Edtech Group

Personalized Online Adaptive Learning System (POALS)

May Carlon, Post-doc and Research Assistant

Metacognition, or the knowledge and regulation of one's thinking process, includes skills such as goal-setting and knowledge monitoring, among others. Multiple research studies have shown that metacognition contributes to learners' academic performance and improves their growth mindset. However, creating a tutoring system that effectively teaches metacognitive skills and evaluates its effectiveness is challenging. Training for metacognition, a domain-independent skill, usually involves learning a domain-specific skill (e.g., mathematics, language, and others) alongside, thus putting a strain on the learners' cognitive resources. One way to manage cognitive resources while using tutoring systems is through applying educational technologies that adapt the learning path based on the learners' characteristics. In this research, we use prompts to help learners develop metacognitive skills along with adaptive learning for the domain-specific instructional materials to lessen fatigue while still ensuring mastery. We also use natural language processing and machine learning techniques to get course quality feedback from the learners' interaction with our tutoring system pictured in the figure below.

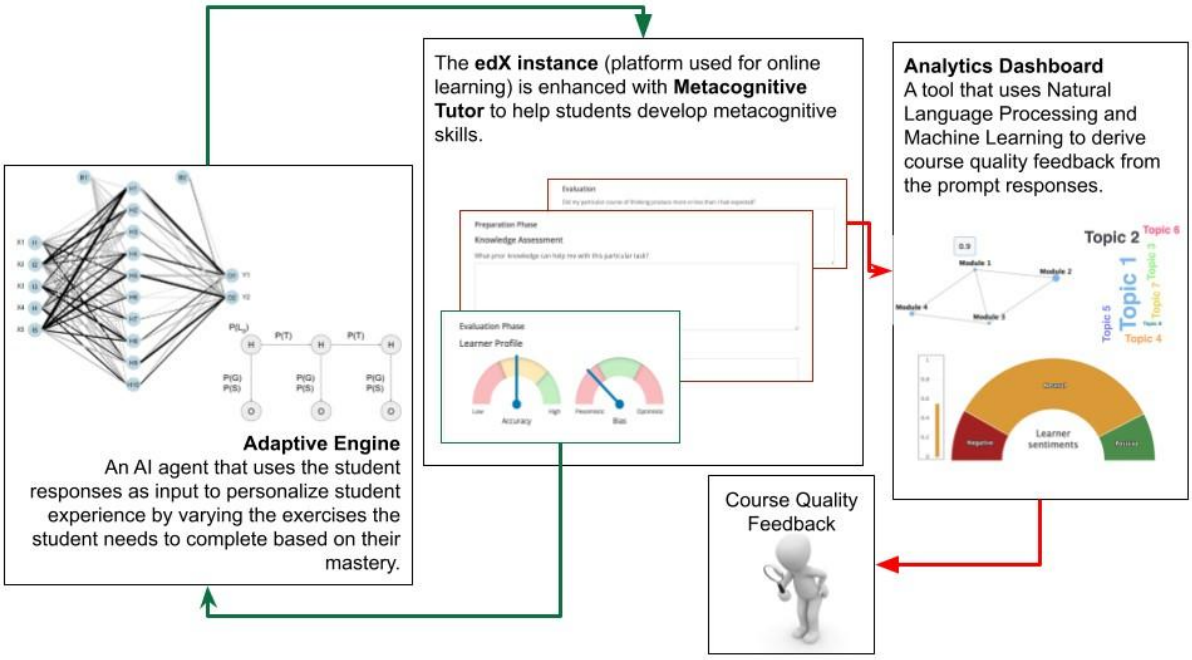


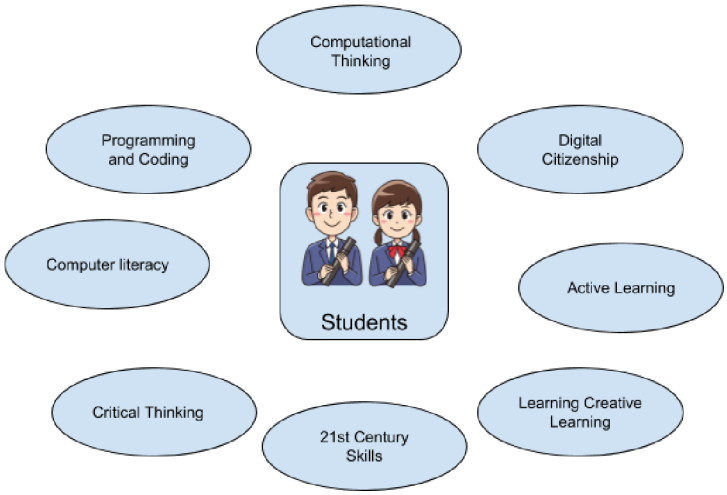
Fig. Personalized Online Adaptive Learning System Overview

Edtech Group

Promoting Students and Teachers to Become Lifelong Learners through Play

Luc Gougeon, GEDES D3+, IGP-C

In 2020, Japanese primary school educators will face the difficult challenge of introducing programming in their classes despite the fact that they never studied programming themselves. Our research aims are mapping the specific contours of the knowledge gap in-service teachers and extend this surveying to current universities students who are also lacking computer literacy skills. Most research in the field of computer literacy places a strong emphasis on children while neglecting the needs of in-service educators and older students. We will tackle this research by both surveying a range of students and teachers while conducting case studies consisting of an education intervention meant to give university students a quick grasp of computational thinking, computer literacy and basic programming concepts. The case study approach intends to offer students essentials skills in an active learning environment, skills which will be transferable to their future workplace or classroom if they intend to become educators. The results of this study are intended to offer stake holders and policy-makers a clearer picture of the current educational landscape and enlighten their decisions. Below is an illustration of summarizing the issues which will be investigated related to education approaches and students' knowledge needs. Fig. below of overall issues in this research



Edtech Group

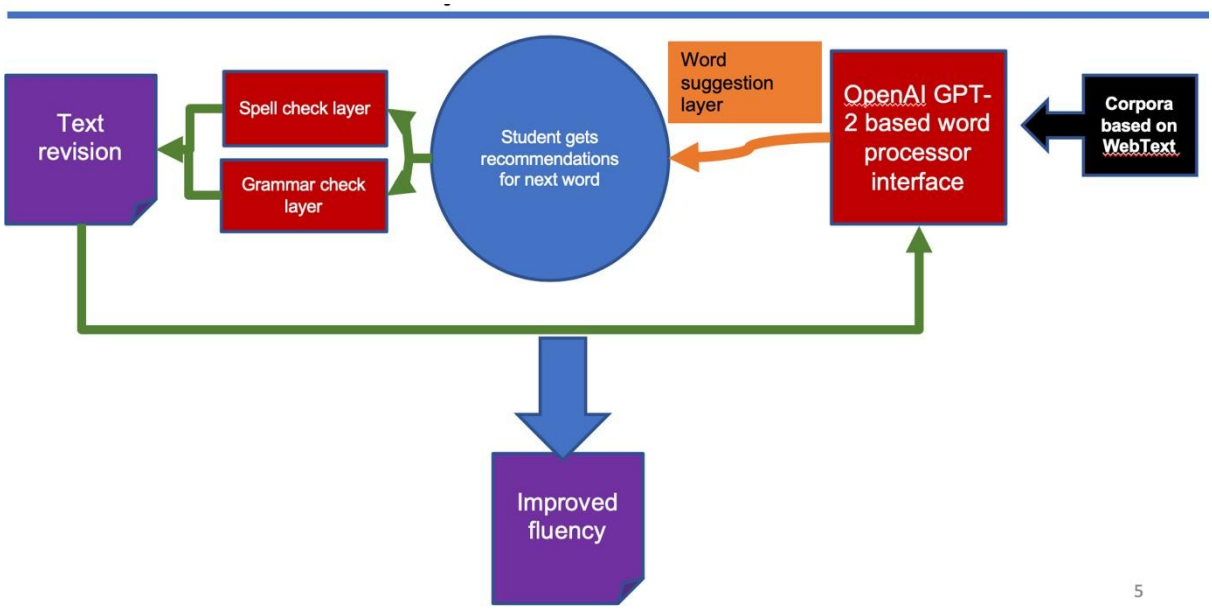
AI-based writing assistants' impact on English language learners' writing fluency

John Maurice Gayed, GEDES D3 student, Working-Adult Doctoral Program

Gayed is a first-year American working adult doctoral student. He is interested in computer assisted language learning, learning management systems, information literacy and digital learning. Gayed is tech enthusiast and full-time university lecturer teaching English for Academic Purposes among other courses at the University of Hyogo's School of Engineering, Himeji, Japan.

Figure Sentence fragment with predicted word use

Gayed is currently researching the potential to use an AI-based writing assistant for second language learners at Cross lab. Little research has been done on how these systems affect L2 writing output and the researcher believes these systems will be as prevalent as spell-checking/grammar checking systems that were first developed more than thirty years ago. He plans to develop these tools to assist Japanese university students who are enrolled in English for Academic Purposes (EAP) courses overcome the various cognitive barriers they face when they attempt to produce written text in English. The researcher is developing the AI system based on Open AI's GPT-2 language model. The expected outcome of the research is that AI-based writing assistants can improve students' writing fluency. Fig. below of research approach.



(1) Allen Institute for AI. Language Modeling Demo. https://demo.allennlp.org/next-tokenlm?text=This%20research%20will%20

Edtech Group

Embodiment and Iconicity for English as a Foreign Language Learning in Virtual Reality

Robert Anthony Olexa, GEDES D2, Working Adult Doctoral Program

Robert Anthony Olexa is conducting research on Japanese students studying English as a foreign language (EFL) in tertiary educational settings funded by a JSPS Kakenhi grant. The research focuses on how students use iconic gestures and embodied communication to acquire English in virtual environments. The compilation of an ongoing Virtual Reality (VR) Chat language learner corpus cross-referenced with video data and multimodal analysis is used to observe how embodied learning contributes to students' EFL learning progress.

Iconicity is a term used to describe communicative elements that closely resemble their referents. A degree of iconicity when communicating between caregiver and learner has been recognized as necessary for first language acquisition. Also, the usefulness of iconic gestures has been intuited by educators for second language acquisition as evidenced through the broader educational approach of "Active Learning," and more concentrated EFL approaches such as Total Physical Response. However, the limitations are known, and the Japanese EFL setting remains situated in the classroom. At current, the learning experience is delivered mainly through passive activities.

Recent advancements in commercial VR technology have allowed for 6 degrees of freedom of movement (see below). Participants can move around in virtual environments with increased space and movement, allowing for embodied communication and iconic gestures. The liberation from a traditional classroom environment can improve EFL teaching and learning in Japan as a whole. Also, the findings may point to needed areas of improvement for software developers and designers of extended reality devices.

Fig. VR aviator of the researcher and use of head mounted display

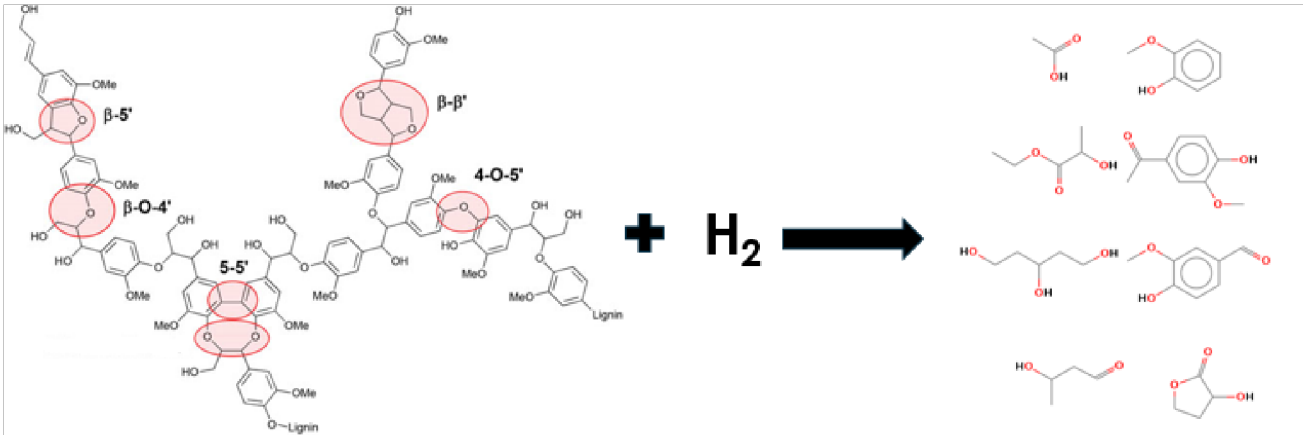
Biochem Group

Effect of hydrogen donors on the catalyzed hydrogenolysis of Kraft lignin

Abraham Castro Garcia, Energy Course, D2, InfoSysEnergy Doctoral Student

Lignocellulose such as wood and crop residue are abundant sources of renewable of biomass and is composed of 15-30% lignin by weight. Cellulose and hemicellulose fractions are used for making paper, but lignin is seen as a low-value waste product that is burnt as fuel to power the paper making process. Lignin is a complex polymer made of phenolic units. It is possible to transform lignin into bio-oil, containing aromatic chemicals which are currently obtained only from crude oil. However, the actual mechanisms behind lignin depolymerization are poorly understood, with only partial understanding of the role that heterogeneous catalysts, lignin properties and choice of reaction media play in the reaction. In particular the large gap in reaction speed between homogeneous and heterogeneous catalyzed lignin depolymerization raises concerns of significant mass-transfer limitations in the reaction that are hard to assess and resolve, due to lignin's variable molecular weight and the way this interacts with surface properties of the catalyst (surface area, pore diameter and pore topology).

Our research aims to study these mass transfer limitations by using a combination of machine learning to develop predictive models for bio-oil yield and reaction speed based on existing data from the literature, allowing us to better understand the variables that impact the reaction, and then corroborate these results with experimental work that will contribute to developing economically feasible lignin depolymerization process.



Lignin hydrogenolysis reaction

Fig. Overall process for conversion of lignin to biofuel using machine learning and chemical reaction engineering.

Biochem Group

Conversion of sewage sludge into pure hydrocarbons (aviation fuels) through Hydrothermal Liquefaction

Usman Muhammad, IGP-A (MEXT Scholarship), GEDES, D2

Sewage sludge is a residual material generated as a byproduct throughout wastewater treatment and has nutrient-rich organic materials. It is a mixture of organics (proteins, carbohydrates, oils...etc), inorganics (e.g., metals) matters, and microorganisms that could be recovered for various economic, social and environmental purposes. We are going forward with the Hydrothermal Liquefaction (HTL) of sewage sludge to produce pure hydrocarbons (aviation fuels) and reduce waste for the environment after successfully extracting organics from sewage sludge and converting them into biodiesel. Hydrothermal liquefaction is a process in which the macromolecules that makeup biomass is hydrolyzed at high pressures (10 – 15 MPa) and average temperatures (280°C – 380°C). Furthermore, this study will concentrate on the design and synthesis of multicomponent catalysts to aid in the simultaneous execution of many reactions in HTL to produce efficient and satisfactory outcomes.

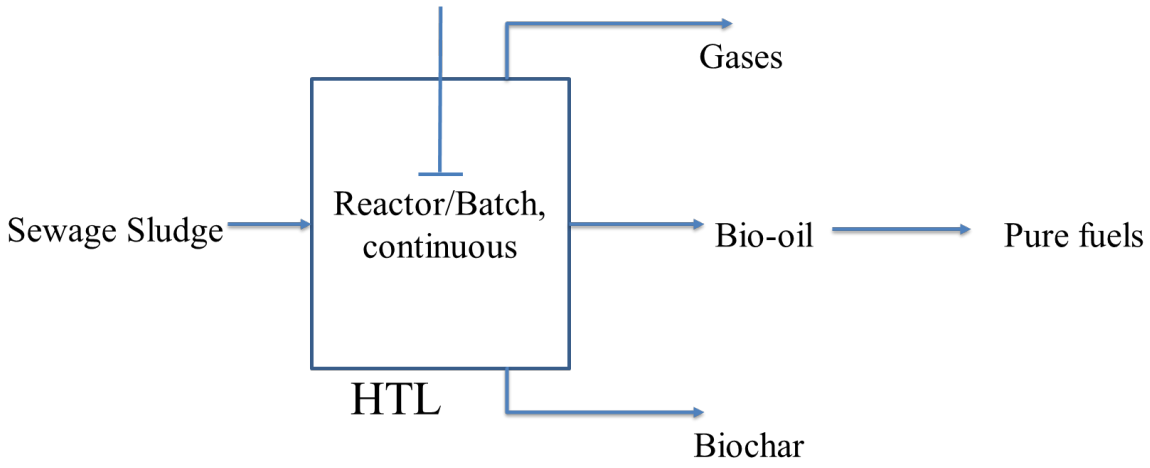


Fig. Overall schematic of HTL process

Glycerol upgrading via thermo-electrochemical deoxygenation (TED)

Muhammad Harussani (M.M. Harussani), Energy Course, MEXT Scholarship, D1

Glycerol is a by-product of the biodiesel production of renewable biomass resources and one of the main surrogates of bio-oil derived from food waste. These materials could not be used directly as fuel or chemicals because of their high acidity, low heating value, presence of high moisture and inorganic impurities content. Therefore, glycerol upgrading is one of the significant mechanisms, comprised of dehydration, deoxygenation, and hydrodeoxygenation, for production of hydrocarbon rich fuel or bio-aviation fuel (BAF) that has similar properties to conventional jet fuel but with a smaller carbon footprint and reduce life cycle greenhouse gas (GHG) emissions. Thus, in our research, a novel approach of thermo-electrochemical deoxygenation (TED) of glycerol at mild temperature and ambient pressure is under investigation. The application of increasing temperature in catholyte and electrolysis of water and glycerol producing two-fold deoxygenation within the system, using novel recombination of thermochemical and electrochemical reactions with small, applied potential between cathode and anode in dual-membrane cell, make TED as promising alternative to upgrade bio-oil into desired isopropanol.

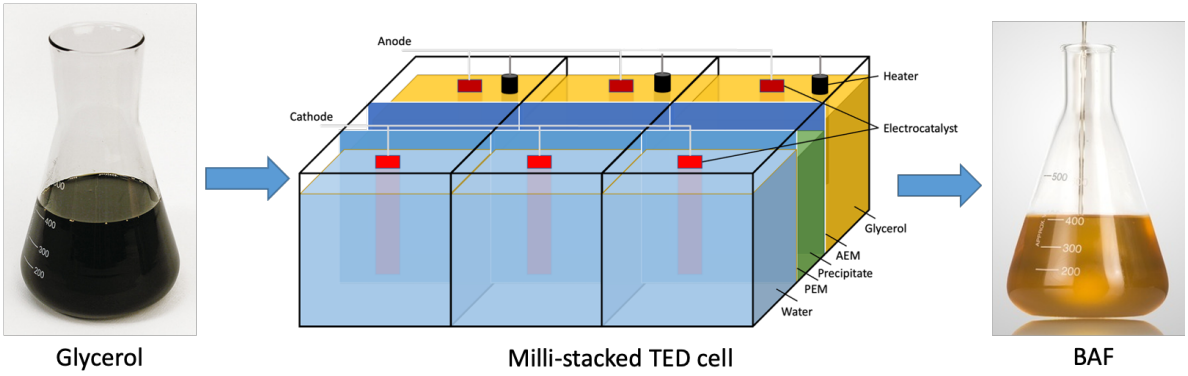


Fig. Overall schematic illustration of TED for glycerol upgrading to isopropanol

Biochem Group

Sustainable Green Chemistry Process to Prepare a Bio-heating Oil from Sewage Sludge

Keang Kimleng, M2, IGP-A (MEXT Scholarship), Energy Science and Engineering

Many industrial manufacturing processes globally rely upon heat-treatment or thermal drying of materials to produce manufactured goods by burning of fossil fuels. There is a great need in industrial processes to reduce the use of fossil fuels in order to achieve carbon neutrality in the near future. To reduce CO_2 emissions in industry, it is important to replace fossil fuel usage with carbon-neutral biofuels. A biodiesel-based heating oil can be extracted from sewage sludge. This process extracts lipids from municipal waste water treatment (MWWT) plant sludge and then measurements the bio-fuel heating values (see below). The production of biofuel from sludge can potentially have economic benefits in Japan and reduce its CO_2 emission as well as have impact in developing countries where heating oil is imported such as in Cambodia. Process optimization and economic analysis will be undertaken.

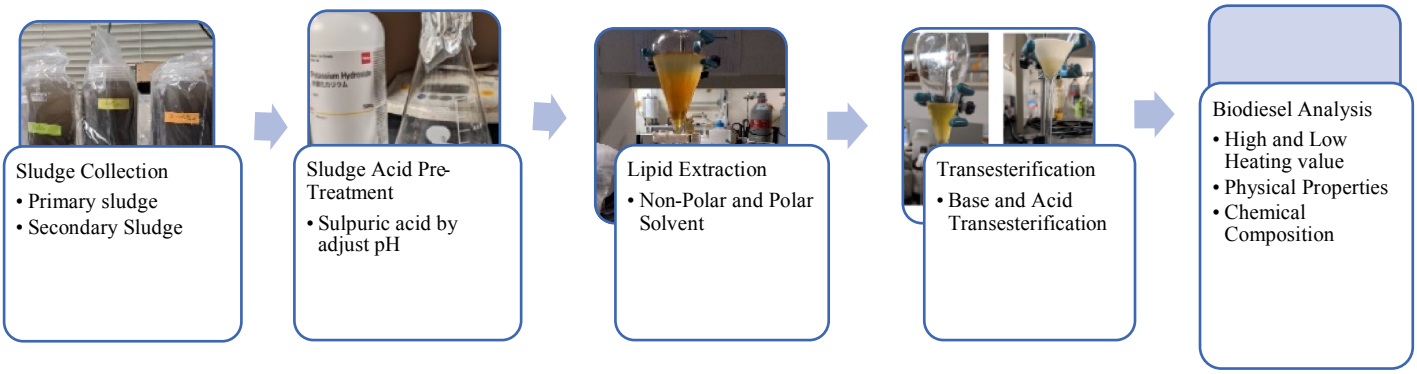


Fig. Proposed research for biodiesel-based heating oil production from municipal sludge.

Biochem Group

Research on biomass gasification using pyrolysis process to produce syngas for maximizing hydrogen yield.

Md. Rubel, M1, IGP-A (MEXT Scholarship), Energy Science and Engineering (Energy Course)

Currently biomass gasification through pyrolysis technology to address global hydrogen challenges in energy is creating a huge amount of attention. In my research, the pivotal matter to consider would be to produce syngas from palm kernels shell (PKS) biomass gasification process for maximizing hydrogen yield. In that case, preparation of an identical (Co-Mo based) and cost effective catalyst will be formulated for gasifying the significant PKS biomass feedstock and the impact of catalyst designs on pyrolysis reactors and subjected to various process parameters and targeted product yield will be revealed evidently. Followed by, the intermediate reflux (IR) ratio for optimum PKS biomass feed charge and syngas volume calculation will be estimated and integration of data processing and machine learning methods for better processing of gasification data will be applied. Assuming that after the experiment, maximum yield of the syngas will be 61.4wt% and CO will be 23.6 wt% and carbon di-oxide will be 15wt.%.

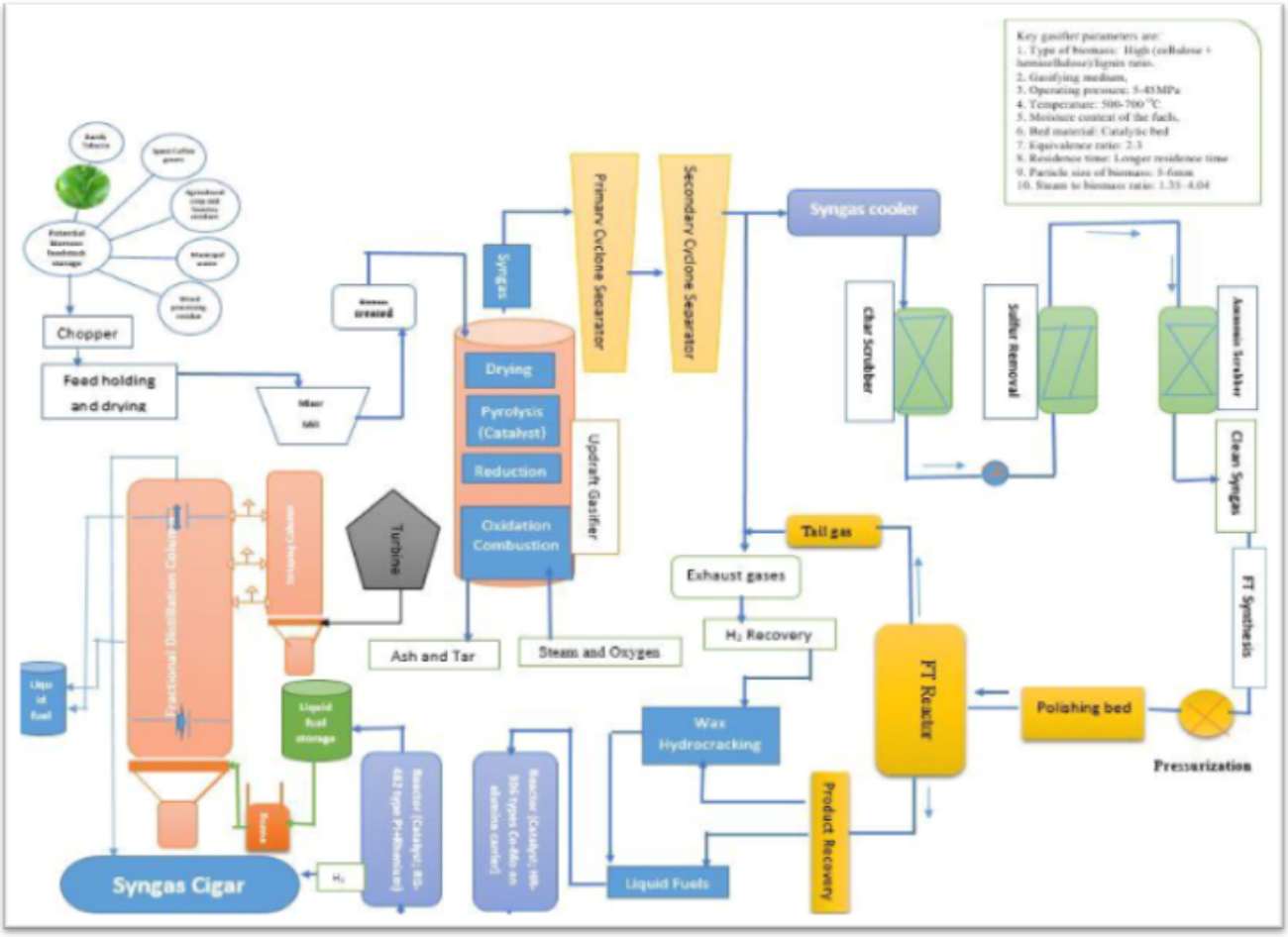


Fig Modified biomass gasification process.

Energy Policy Group:

A multi-energy complementary microgrid superstructure model utilizing renewable energy：Case study of Northern China

Hu Dongzi, M1 student, IGP(C) Energy course

Recently, Northern China still mainly depends on coal to generate electrical power with limited use of renewable energy which is bad for the environment. The Chinese government is working solving environmental pollution and energy shortage. In Northern China, the potential for renewable energy utilization is huge and Smart microgird can be regarded as the alternative solution to incorporate renewable energy in the local grid.

Through this research, a smart microgrid configuration will be proposed as a case study based upon the use of Matlab software. More renewable energy would be integrated to supply reliable, economical and environmental-friendly electricity. Peer-to-peer (P2P) energy trading system (see fig. below) is the power control and operation will also be considered. Distributed energy resources are traded among local consumers and prosumers. It means they can decide from which source and when they purchase electricity. P2P energy trading would be backed up by blockchain that enables consumers to trade energy safely, directly and economically.

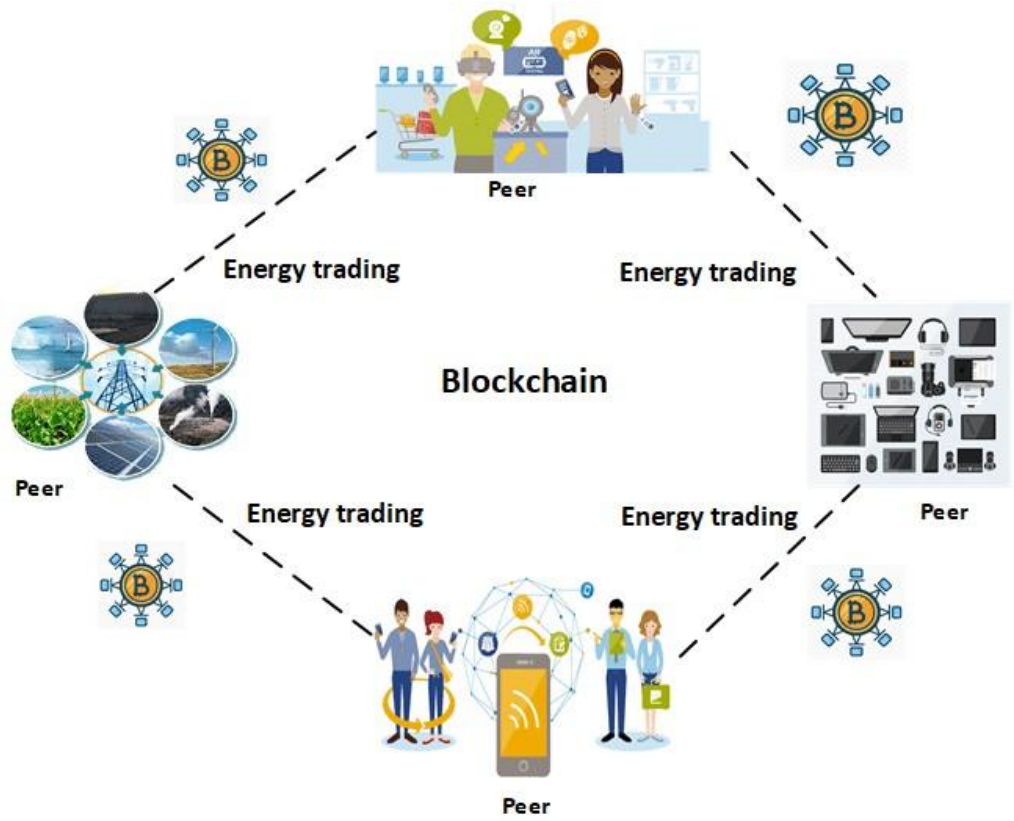


Fig. Peer-to-peer energy trading system utilizing blockchain in a smart microgrid (Gurman et al, Energy Trading between Prosumer and Consumer in P2P Network Using Blockchain, Conference: in the 14th International Conference on P2P, Parallel, Grid, Cloud and Internet Computing (3PGCIC-2019). 2019)

Energy Policy Group:

Modeling of the solar power output forecast system for Hyderabad Railway Station (India) using Transfer Learning and Hidden Markov Model

Jinesh Mohan M1 student, IGP(C) Energy course, MEXT Scholarship

Indian Railways has set an ambitious target of becoming a net carbon-zero transporter by 2030. With the rapid adoption of photovoltaic (PV) systems on the railways and their integration into the electricity grid, it has become a necessity to accurately forecast the photovoltaic output at their intended site of use for effective energy management to mitigate the instability of the grid caused by the intermittency of solar power. The literature shows that transfer learning and Hidden Markov Models (HMM) have shown promising results in various applications. However, the scarcity of data in new installations is a big impediment to effective energy management. The research aims to model a solar power forecast system using transfer learning from a pretrained HMM model capable of predicting solar irradiance using the weather parameters as inputs. The real data of the solar power output of Hyderabad Railway Station in India is used to test the results. The input weather parameters (Global Horizontal Irradiance, Temperature maximum, Skin temperature, humidity, and wind speed) from the Indian Meteorological Department and the solar power output from the datalogger of the plant will be used to train and test the model. See figure below for overall concept of the research in general.