FIELD OF STUDY

Chemical Engineering

DISSERTATION TOPIC

**Multi-Scale Modeling of Biomass Pyrolysis –
Macro- and Meso -Scale Modeling**

EXAMINING COMMITTEE

Dr. Joseph Biernacki (Professor, Chemical Engineering)

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ABSTRACT

Biomass pyrolysis is the thermal decomposition of lignocellulosic matter in an inert environment and is considered to be one of several alternative renewable and sustainable sources of chemicals and fuel precursors for the replacement fossil carbon. Kinetic parameters for biomass pyrolysis were estimated using a newly proposed mathematical analysis for the reduction of thermogravimetric data. Several factors that affect kinetic parameters and their interrelationships were considered. The key contribution of this kinetic study was to identify the importance of the optimization strategy, noting that numerous seemingly feasible false optima are possible. The findings are applicable in all scientific and engineering fields that require estimation of parameters from Arrhenius-related kinetics; field such as biology, semiconductor, biotechnology, physics, etc. Modeling biomass pyrolysis is very complex because it is a multi-component, multi-scale and highly heterogeneous process. Prevalent models, based on continuum platforms that depend upon direct solution of differential equations have not been able to satisfactorily capture the heterogeneity aspects of biomass pyrolysis. In this work, a novel multi-scale kinetic cellular automata-based computational platform was used to model biomass pyrolysis with the purpose of extending the capability of known pyrolysis models by capturing microstructural changes that take place during biomass pyrolysis at mesoscopic length scales. For the first time, a technique that uses actual biomass images acquired from transmission electron microscopy (TEM) and X-ray micro-computed tomography (μCT) was demonstrated. A shrinkage mechanism was proposed from experimental observations and testing of hypothesis using computational alternatives. Finally, pyrolysis-induced structural changes (including shrinkage and porosity) of biomass of arbitrary geometry was modeled, thus making it possible to predict thermo-kinetic properties that are dependent on porosity and shrinkage as a function of time and reaction temperature. Both the kinetic parameter estimation strategy and mesoscopic microstructural model should advance the effort to expand the emergent biofuels industry and associated technology for direct thermochemical conversion of biomass to liquid fuels (BTL) and chemicals.

BIOGRAPHICAL SKETCH

Michael Oluwaseun Adenson was born in Lagos, Nigeria. He received his B.S. degree in Chemical Engineering from University of Lagos, Nigeria, where he modeled microbial growth in a batch culture using stochastics. He proceeded to Newcastle University, UK on a national scholarship, where he acquired M.S. degree in Applied Process Control; there he modeled and controlled a tubular reactor carrying out an exothermic reaction. He has extensive modeling and simulation experience in wide engineering practice. He is married to Sabina Gbadegesin and blessed with a beautiful baby girl (Victoria Yewande Adenson).

EDUCATION

M.S., Applied Process Control, Department of Chemical Engineering And Applied Materials, Newcastle University, Newcastle upon Tyne, UK, 2011- 2012

B.S. Chemical Engineering, Department of Chemical and Petroleum Engineering, University of Lagos, Nigeria, 2004 – 2009

College of Engineering

TENNESSEE TECH

The Department of

Chemical Engineering

Announces the Dissertation Defense

Of

Michael Oluwaseun **Adenson**

In Partial Fulfillment of the Requirements

For the degree of

Doctor of Philosophy

Thursday, 13th of July, 2017

(2:00 PM)

Held at

Brown Hall, Room 208

1020 Stadium Drive, Tennessee Technological University Cookeville, TN 38505