A Comparison Study of Thermal Insulation Properties of Gadolinium Zirconate ($Gd_2Zr_2O_7$) and Yttria Stabilized Zirconia (YSZ)

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This study focuses on the preparation and thermo-physical properties characterization of $Gd_2Zr_2O_7$ films deposited on IN738 substrate. The properties measured are utilized in a thermal modeling of a turbine blade deposited with $Gd_2Zr_2O_7$ and compared with YSZ coated turbine blade. Pyrochlore-structured rare-earth materials have been used recently as thermal-barrier coating materials because they show low thermal conductivity due to the oxygen vacancy. The goal in this study is the estimation of temperature distribution in the turbine metal substrate (IN738) and coating materials, ($Gd_2Zr_2O_7$ vs. YSZ). Isothermal conditions (1573 K) are enforced around the turbine blade. The heat conduction in the turbine blade and TBC systems necessary for the evaluation of substrate thermal loads are evaluated. The steady state 2D heat diffusion in the turbine blade is modeled using ANSYS FLUENT computational fluid dynamics (CFD) commercial package. Radiation is fully accounted for by solving the radiative transport equation (RTE) using the discrete ordinate method. Increased temperature drops across the TBC leads to temperature reductions at the TGO/bond coat interface which slows the rate of the thermally induced failure mechanisms such as CTE mismatch strain in the TGO layer, growth rate of TGO, and impurity diffusion within the bond coat.

Investigation of Role of $Gd_2Zr_2O_7$ Powders in Improving Life of Thermal Barrier Coatings

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Thermal barrier coatings (TBCs) are being utilized to achieve higher processing temperatures in advanced gas turbine, necessary to achieve postulate engine efficiencies. Gadolinium zirconate $Gd_2Zr_2O_7$ (GZ) offer the advantage of having no phase transition during thermal aging and can maintain lower thermal conductivity (8.1~10.5 x $10^{-6}K^{-1}$at 200~1000^oC) than YSZ. In high temperature applications thermal cycling life is affected by growth of aluminum oxide (TGO). Below 1100^oC, the reaction between GZ and Al_2O_3 is very slow. Previous research shows that due to the smaller thermal expansion coefficient ($9x10^{-6}K^{-1}$-$10x10^{-6}K^{-1}$) and lower fracture toughness (1.8 MPa.$m^{1/2}$-2.1 MPa.$m^{1/2}$) thermal cycling life of single layer GZ is much shorter than YSZ. Functionally graded TBC's with 7wt.%YSZ as a bottom layer and $Gd_2Zr_2O_7$ as top layer is a newly proposed TBC top coat structure. Mechanical properties like Coefficient of Thermal Expansion (CTE), hardness and young's modulus which leads to thermal stresses should be carefully investigated before predicting the appropriate function for the top coat. This paper presents study and results concerning the Thermal cycling tests, CTE measurements and other thermo mechanical properties of the powders intended for deposition as multi layered TBCs. The study compares the pure YSZ coatings to pure GZ coatings, GZ and YSZ mixture coatings and double layered GZ/YSZ coatings to investigate the best suited function of GZ and YSZ. The temperature range of the tests was 25^0C to 1300^0C. The samples are processed using Air Plasma spraying (Ø -12.7 mm, length 2 mm).

Use of Local Louisiana Cultivar of Gamagrass for Bioethanol Production

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Our need for alternative and cleaner liquid fuel is ever growing because of the dwindling supply and increased price of oil for the past ten years. Lignocellulosic ethanol production is an attractive option to meet the demand of energy for the transportation sector of our country. The production of ethanol from gamagrass (*Tripsacum dactyloides*) is very attractive because it grows very well in the wet and marshy environment that is common to southeast Louisiana. Gamagrass is also a native perennial grass, which is commonly found in Louisiana and eastern United States. Gamagrass grows on marginal land and will not take up the valuable agricultural land for energy production. The purpose of this study was to demonstrate locally grown gamagrass could be effectively used to produce ethanol. We optimized pre-treatment conditions to remove lignin and also effectively used enzymes, cellulase and xylanase to produce glucose and xylosic sugars from cellulose and hemicellulose components of gamagrass. These sugars were used for fermentation with a recombinant *E.coli* FBR 5 capable of fermenting glucose and xylose simultaneously. The results indicated that the use of cellulase enzyme produced 2,356 mg/L ethanol and the use of xylanase enzyme yielded 1,301 mg/L ethanol. The enzyme cocktail of cellulase and xylanase produced the maximum ethanol yield of 6,002 mg/L within nine days of fermentation. Further studies are needed to scale up the fermentation process to pilot scale and eventually commercial scale to meet the energy demand of our country.

The Cost of Producing Fermentable Sugars for Biofuels from Sweet Sorghum (*Sorghum Bicolor*) and Energy Cane *(Saccharum Spp*.)

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The expansion of domestic biofuel production capacity is limited by both the availability of feedstock and the costs associated with conversion to fermentable sugars. It has been estimated that a price for fermentable sugars within the range of 10-15 cents/lb would allow biofuels to be competitive with fossil fuels. With this benchmark in-mind, a case study was developed that concentrated on the cost of producing fermentable sugars from two biomass crops, sweet sorghum and energy cane. These crops were chosen because they contain both simple sugars and biomass-fiber and can be harvested, transported and processed using infrastructure which is in-place and mature in Louisiana (cane-sugar industry). Measurement of the sum of fermentable sugars that can be produced from expressed juice and the lignocellulosic component (via alkaline pretreatment and enzyme hydrolysis) suggested that pound-for-pound, fermentable sugars suitable for biofuel production can be produced from these crops at a cost approximating the value of fermentable sugars in blackstrap cane-molasses, currently about $0.125/pound.

Torrefaction of Biomass for Use as an Alternative Power Plant Feedstock as Compared to Coal

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Torrefaction is a pretreatment technology that is capable of converting biomass, such as wood chips, into a feedstock that has been energetically densified and biologically stabilized which improves the value of the product as a potential replacement to coal for power generation using combustion processes. Using both laboratory and pilot scale reactor units, a series of tests have been completed to evaluate optimal conditions for producing an acceptable product and determine optimized reactor operational factors. Results are very promising and have resulted in efforts to commercialize the process. The presentation will summarize both technical and economic data that support further development of the process.

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Evaluation of Methane Production from Novel Waste Streams using Advanced Digestion Methods

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A series of laboratory assessments have been on-going that are defining the potential for producing methane from landfill leachates, shrimp processing wastes, and crab processing solids using digestion processes with hopes of finding alternative sources of methane that can also solve environmental waste management challenges. The results are varied in terms of rate and extent of methane production. However, all feeds show tremendous potential for implementing digestion at these facilities. The application of various amendments and changes to process operations were attempted to reduce cost and optimize methane production. Additionally, a novel, mobile pilot digestion system has been designed and preliminary results from its operation presented. The presentation will also detail projected process economics.

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Reducing the Cost of Microbial Lipid Production from Carbohydrate Rich Waste Streams

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Microbial lipid production from oleaginous yeast *Lypomyces starkeyi* was studied using soluble sweet potato starch as carbon source. Economics of lipid production was analyzed and it was found that medium cost, operating cost and solvent cost are the major cost contributing factors. Medium optimization was done by response surface methodology to replace yeast extract with vitamins. The concentrations of phosphates in medium were also optimized. High density cultivation experiments were conducted in a 5L New Brunswick Fermentor with different C/N Ratio. Extraction of lipid from yeast cells were analyzed with different solvent system using wet and dry cells and also with bligh & dryer method and accelerated solvent extraction (ASE) method. The results obtained from the above experiments were utilized to simulate the biodiesel production process in Aspen plus. The economics of the complete production process will be presented with this work.