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## CHEMICAL ENGINEERING (CHE)

**CHE 200001 ARQUIZA, Apollo C. (MS Chem. Eng'g.)**
**The Effect of Using Pelletized Media on the Production of Alpha-Amylase by Solid State Fermentation. 2000**

The study investigated the effect of using pelletized media on the performance of a solid state fermentation (SSF) system, particularly on an aerated packed bed bioreactor. The SSF utilized Aspergillus oryzae grown on a rice bran-cassava starch medium (10:1 mass ratio) to produce α-amylase. The pelletized medium had an effective diameter of 5 mm compared to less than 0.833 mm for the unpelletized one. The column bioreactor used had a diameter of 100 mm and a total bed volume of 1.3 dm3. At an aeration rate of 1.20 vessel volume per minute (vvm) and 84 hours fermentation time, the pelletized medium gave a yield of 589 dextrinizing unit (DUN)/g dry medium compared to 179 (DUN)/g dry medium for the unpelletized medium at the same conditions. Compared to that reported for SSF in static trays, the pelletized medium gave 6.52 greater value. At 3.40 vvm aeration rate, the yield (pelletized medium) was 611 DUN/g dry medium, which was 1.55 times that for the unpelletized medium and 5.44 times that for trays.

The effects of aeration rate and length of fermentation were further investigated for the pelletized medium. The results show that the yield of α-amylase did not vary significantly (α = 5%) for aeration rates of 1.20, 2.06, 2.81, and 3.40 vvm. This lack of effect may be explained by the contributions of the conduction and convection heat transfer in the bioreactor. It was possible that the convection heat transfer in the contributions of the conduction and convection heat transfer in the pelletized media had been greatly increased so that the gas phase resistance was negligible compared to the conduction resistance. As such, variations in the aeration rate would no longer affect the total rate of heat transfer. This implies that SSF using pelletized media does not require high aeration rates. A fermentation time of 120 hrs. produced α-amylase yields which were 60% greater than that for 84 hrs. This was attributed to secondary growth from the spores produced by the initial inoculum.

The study showed that the use of pelletized media for production of α-amylase in SSF by *Aspergillus oryzae* in an aerated packed bed bioreactor gave yields that were greater than that for unpelletized media and trays. Further study is therefore recommended to fully develop this process for large-scale SSF.

**CHE 199702 BADILLA, Daisy B. (MS Chem. Eng'g.)**
**Freeze Concentration of Coconut Water. 1997**

This study deals with a single stage concentration of coconut water. Coconut water was partially frozen and the ice crystals were separated to produce concentrated coconut water. The following factors were studied: initial concentration of coconut water, weight of ice crystals, concentration of ice crystals, and cooling rate. To recover the solute adsorbed or entrapped in the ice crystals, procedures to wash the ice crystals were devised.

The following results were obtained: At lower concentrations, freezing time was shorter. Large ice crystals adsorbed less solute and gave a higher concentration of the coconut water concentrate. Slow freezing or indirect cooling produced the large ice crystals. Solute recovery was more efficient in the washing of large ice crystals than in the washing of fine ice crystals. Empirical equations were obtained to show the effect of weight of ice crystals on concentration of the coconut water concentrate and of the ice crystals.

Based on the results of this study, a design of the freeze concentration process and the corresponding equipment is proposed.

**CHE 200103 BENDANILLO, Yuri P. (MS Chem. Eng'g.)**
**The Use of Lahar Particles as Immobilizing Medium of Titania in the Photocatalytic Degradation of 2,4-Dichlorophenol**

This study focuses on the photodegradation of 2,4-dichlorophenol with the aid of titania immobilized in lahar particles as catalyst. It also determines the effect of lahar particle size, light intensity and initial concentration in the photodegradtion of 2,4-dichlorophenol. Immobilization of titania on lahar particles was done using an oven

heated to 200°C. Two sources of light were used: 10-watt V lamp and solar energy.

Variables considered in the first set of experiment were lahar particle size and light intensity while for the second set were lahar particle size and initial concentration.

The immobilization result of titania on lahar particles showed that larger lahar particle size has more adherence capability than the smaller one. This may be supported by the fact that the surface of larger size is more rough which in effect has the capacity to hold more titania in the immobilization process.

Light intensity has a direct effect on photodegradation of 2,4-dichlorophenol. It is noted that as light intensity increases, the amount of 2,4-dichlorophenol being degraded also increases.

Lahar particle size has no effect when no light is subjected on the system. In the presence of light however, result showed that degradation is higher when $TiO_2$ is immobilized on bigger lahar particle size. This could be explained by the fact that more amount of titania was present in larger lahar particle size which indirectly means that catalyst loading is relatively higher.

The result also showed that photodegradation conversion of 500 ppm 2,4-dichlorophenol is lesser than that of 100-ppm initial concentration. The photodegradation conversion of 2,4-dichlorophenol decreases with the increasing initial concentration.

**CHE 199704 BUQUE, Evelyn M. (MS Chem. Eng'g.)**
**Purification Methods of Lipase From *Rhizopus delemar***

Purification of lipase is studied on the basis of the solubility of lipase on ammonium sulfate. This includes the determination of (a) optimum pH for minimum solubility and (b) optimum salt concentration for effective precipitation of the protein.

Lipase was prepared from *Rhizopus delemar* using the following steps: (1) culture method of the micro-organism; (2) production of lipase, which is done by shake-flask fermentation at room temperature; and (3) purification of lipase by precipitation.

Results did not show satisfactory indications of the optimum pH and salt concentration for the effective precipitation of lipase. This may be due

to the ammonium sulfate which have interfered considerably with the assay since dialysis of supernatant liquid was not done. Trace metals present in water may have inhibited the activity of the enzyme.

**CHE 199505 CONSIGNADO, Lenita J. (MS Chem. Eng'g.)**
**Process Variations in the Production of Gluconic Acid and Glucose Oxidase by Fermentation Using *Penicillium funiculosum* 4072. 1995**

Ten-liter fermentation runs were conducted to investigate some production processes for gluconic acid and glucose oxidase by *Penicillium funiculosum* 4072. The results of the batch fermentation with recycling of mycelia show that we can re-use the mycelia. Using 10% glucose in the medium, high enzyme activity coupled with high production of gluconic acid were obtained every 24 hours. In the fed-batch addition of nutrients, two methods of nutrient feeding were investigated: semicontinuous addition of glucose only (other nutrients charged at the start of the process). The results show little difference in the rate of fermentation. Yield of about 90% was obtained for both methods after 36 hours. The peak of enzyme activity was observed after 18 hours at 686 units/L for the former and 663 units/L for the latter. Both processes were not optimized which account for low level of glucose oxidase activity. In the fermentation using various concentrations of glucose of up to 25%, the 20% units/L after 24 hours with maximum calcium gluconate yield of 88% obtained after 48 hours.

**CHE 199806 DACUYAN, Rebecca R. (MS Chem. Eng'g.)**
**Adsorption of Fish Lipids on Sludge Particles. 1998**

A major problem encountered in the anaerobic digestion of the waste is the adsorption of fatty solids on sludge which causes a decrease in the rate of anaerobic reactions and sludge wash-out due to flotation. Adsorption of lipids on sludge and other surfaces adversely affect the treatment process. So far, there is hardly any study on the effect of different factors that could influence adsorption of fish lipids and proteins on sludge particles. In this study, the effects of pH, temperature and type of adsorbent on fish lipid adsorption were determined.

Instead of an actual fish processing wastewater, fish slurry prepared using Indian oil sardine (*Sardinella longiceps)* was used in the experiment. In batch experiments, fish wastewater was stirred for 30 minutes at given pH and temperature conditions and decanted to determine its effect. Lipids in the sludge were determined. The pH maxima for fish lipid adsorption on anaerobic sludge at 30°C were found to be between 4 and 6. In the pH range 4 – 9, the adsorbed lipids on glass beads is independent of pH. The amount of lipids adsorbed in the sludge has a minimal at temperature between 25 and 40°C. In the temperature range 20 – 50°C, the adsorbed lipids on glass beads is independent of temperature.

**CHE 200007 DELA CRUZ, Ernesto O. (PhD Chem. Eng'g.)**
**Molecular Imprinting of Methyl Pyrazines. 2000**

Synthetic polymers selective for 2,5-dimethylpyrazine (DMP), 2,3,5-trimethylpyrazine (3MP), and 2,3-methylpyrazine (23MP) were prepared by molecular imprinting. Methacrylic acid was used as functional nomomer and ethylene glycol dimethacrylate as crosslinker. Polymerization was carried out at 4°C using UV photoinitiation and chloroform as solvent. The polymers were ground, sieved and packed in chromatography columns.

The columns demonstrated good selectivity for each of the templates when 95% chloroform and 5% acetonitrile was used as mobile phase. The dependence of the capacity factor on the eluent composition was found to follow the Snyder-Soczewinski equation which describes retention in adsorption chromatography. The polymers also showed selectivity against a range of analogous flavor compounds.

The separation of DMP from 2,6-dimethylpyrazine (26MP) was shown with resolutions of up to 1.35. Lower resolutions were obtained for the separation of DMP from 3MP and 23MP. Peak tailing was significant and was attributed to the presence of binding sites having different affinities for the template.

Studies on complex formation in the eluent showed the existence of two-point binding interactions between DMP and methacrylic acid. The imprinting of 2,5-dimethylpyradine showed the feasibility of one-point binding interactions. The thermodynamic equilibrium constants for

complex formation ($k_1$ and $k_2$) were estimated to be 10.2 and 2.6, respectively. A simulation of the pre-polymerization complex formation showed that the optimum template to monomer ratio for this case was 1:1. This was supported by the rebinding studies which showed the highest retention factor for this polymer.

**CHE 199908 DOMA, Bonifacio T., Jr. (PhD Chem. Eng'g.)**
**A Rotating Fibrous-Bed Bioreactor for Xanthan Gum Fermentation. 1999**

Xanthan gum is one of the most important polysaccharides. Its industrial production by fermentation is limited by oxygen transfer, which is due to the sudden increase in the apparent viscosity of the broth. An increase of 7.5%(w/v) in the xanthan concentration caused an approximately 1,210-fold increase in the apparent viscosity of the solution and a 52% drop in the solubility of the oxygen in the xanthan solution. The oxygen transfer is so severe that even at a lower product concentration (less than 3% w/v), the cells, *Xanthomonas campestris,* stop all their biosynthetic activities. To remedy this problem, the pseudoplastic property of the xanthan gum solution was harnesed. By increasing the shear rate via the replacement of gravity with centrifugal force, the apparent viscosity of the xanthan solution can be decreased. To implement this effect, the original design of the rorating packed bed (RPB) was adopted, and from this, the new fibrous bed bioreactor (RFBB) system was developed. This RFBB system is an improvement of the centrifugal packed bed bioreactor (CPBB) by Lo *et al.* (1995). In this new system, a recirculating vessel was added in order for the bioreactor to be operated in a strictly gas-continuous mode and instead of bubbling the sterile air in the fermentation broth, it was supplied directly at the bottom of the rotor through a sparger. The new bioreactor can be operated at a high rotational rate of 1000 rpm, a radical improvement over the maximum rotational rate of 400 rpm of the CPBB. By recirculating the broth in the rotating packed bed, cells were retained in the bed, allowing the fermentation to be operated in a series of repeated batches. The continuous reduction in the apparent viscosity of the broth, due to its constant recirculation in the rotating fibrous bed at a high pumping shear, allowed the fermentation to proceed even at a relatively high xanthan concentration. The maximum product concentration obtained was ~75 g/L, by far the highest reported value.

The immobilization studies on X. campestris in 100% cotton fibers packed inside the rotating bed indicated that the mechanism is purely retentive and unstrict. The amount of cells were immobilized at high rotational rates (about 20% at 800 rpm), these were enough to conduct the fermentation in a repeated batch mode without profound effects in the subsequent fermentation.

The effects of the different operating parameters on the volumetric productivity and product yield were done during the repeated batches. It was found that the volumetric productivity increased with rotational rate and glucose-to-yeast extract ratio, but had no significant effect in the changes in the air flow rate. The highest volumetric productivity achieved was ~ 1.6 $gL^{-1}$ $h^{-1}$, a threefold increase relative to the conventional xanthan fermentation conducted in stirred tank bioreactors. Similarly, the xanthan fermentation in the RFBB has a characteristically high product yield, YP/S. Fermentation done at rotational rates ≥ 400 rpm has product yields greater than 88%.

To have a better understanding of the characteristics of RFBB, studies on mass transfer, power consumption, average residence time, and liquid holdup were done against different design and operating parameters.

In general, an increase in shear, caused by the increase in the applied centrifugal force or in the pumping rate, was translated into a mass transfer intensification. The volumetric mass transfer coefficient, $k_La'$, increased with increasing rotational and recirculation rates and with decreasing liquid volume. But it decreased with increasing xanthan gum concentration. In the purview of the xanthan fermentation, $k_La'$ was found to have no significant dependency on air flowrate due to the absence of the bed pressure drop. Although the bed thickness may have a significant effect on $k_La'$, the thickness of the bed used did not show any dependency.

For xanthan gum fermentation, the oxygen transfer rate (OTR) is more meaningful than $k_La'$. When the OTR was compared to the specific oxygen demand (SOD) of the X, *campestris,* the critical mass of the immobilized cells that can be supported by the system was found to decrease with increasing xanthan concentration.

The power consumption of the RFBB was found to be affected solely by the rotational rate of the bed. Since the power consumption increased exponentially with the rotational rate, it can be correlated that mass transfer intensification is coupled with a concomitant increase in the

power consumption.

With the use of a KCl tracer solution, the average residence times of the liquid elements inside the bed were found to be in the range of 9-42 s, depending on the liquid and gas rotational rates and the concentration of the xanthan solution. The average residence time of the liquid element was evaluated to be decreasing with increasing liquid or gas rotational rates and increasing with increasing xanthan gum concentration. The liquid holdup inside the rotating bed was computed from the average residence time. A correlation was proposed for the liquid holdup vis-a-vis the ratio of liquid and gas rates.

Different mathematical models were adopted and modified to delineate the mass transfer specifies inside the RFBB during the pseudoplastic fermentation. It was found that the rotating disk models (the complete convection-diffusion and penetration theory) are adequate to predict $k_L$, especially at high xanthan concentrations. Based on the rotating disk model and dimensional analysis, a correlation was derived by fitting the experimental data for the volumetric mass transfer coefficient for the proposed model. In turn, this correlation was used to predict the change of $k_L$ during the xanthan gum fermentation.

**CHE 200109 ESCOTO, Angela D. (PhD Chem. Eng'g.)**
**Heat Transfer Through a Hybrid Wall Attachment with a Water-Cooled Absorber. 2001**

This study investigates the heat transfer through a tube an sheet assembly refereed to as the hybrid wall attachment configured using horizontal, parallel copper tubes attached to an aluminum sheet. The final objective is to prevent or at least minimize warming up of concrete walls that are exposed to solar irradiation. To this end, the metal sheet assembly will eventually be attached to the external surface of the concrete wall and direct cooling can be achieved by pumping water through the tubes. This heat transfer study involves the determination of the following parameters for the hybrid wall attachment: (1) system time constant, (2) achievable cooling indicated by the final temperature of the sheet, (3) heat transfer coefficients for convective heat loss to the ambient air and loss to water, (4) temperature profiles across the metal sheet, (5) recommended tube spacing, and (6) water flow rate. Mathematical models for the time variations of the sheet temperature during flow and for

the case of no water flow were developed and compared with experimental data. Numerical solutions to the partial differential equations using an explicit method were used to map the temperature profiles of the sheet. Suggested mathematical equations for the solar flux and ambient temperature variations with time for local conditions were also obtained. From the results, theoretical predictions of the wall performance were made and the advantages/disadvantages in connection with its use were assessed.

**CHE 200010 GARCIA, Corazon M. (PhD Chem. Eng'g.)**
**Ion Separation from Dilute Electrolyte Solutions by Nanofiltration. 2000**

Nanofiltration (NF) is a pressure-driven process which is considered potential for the separation of ionic species selectively from solutions containing mixture of electrolyte solutes. The lower operating pressure requirement of NF than reverse osmosis (RO) makes the earlier potentially economical.

In the separation of ions, many authors believed that there are membranes with characteristic fixed surface charge and that the mechanism of separation of ions is by the differences in valences of the ions.

In this study, experiments involving dilute single-solute and multiple -solute electrolyte solutions were performed using three different NF membranes. Permeate fluxes and ion rejections of the different species of ions in samples of permeate solutions were measured at varied conditions. The mechanism of separation in NF was determined based on the analysis of the trends and behavior of ion rejection relative to the solution temperature, pressure, type of solute, feed concentration and feed solution pH. The results of the experiments show that there is no evidence of the presence of fixed surface charge on the NF membranes. Ions having higher hydration numbers showed higher ion rejection than those having lower hydration numbers.

A method to determine the effective membrane pore size of NF membranes using hydrodynamic model was proposed. The proposed method is based on the assumptions that the membrane is neutral and that the separation is based on sieving effect.

**CHE 199911 GUMASING, Myra dR. (MS Chem. Eng'g.)**
**A Rotating Cylindrical Bioreactor for Nata de Coco Production. 1999**

A prototype of a newly designed bioreactor which can produce nata de coco on the surface of a rotating cylindrival roller was fabricated and evaluated using *Acetobacter xylinum.*

The results showed that both DOST and UPLB strains of *A. xylinum* produced nata de coco with the latter giving a higher yield and thicker pellicle in 10 days. Less yield and thinner pellicle was produced as compared with that from the static culture. During cellulose production, the pH of the medium did not change considerably while the titratable acidity decreased as the process progressed. However, the sugar concentration of the medium fluctuated due to cellulose's liquid absorption and medium evaporation.

The microbial count of the bioreactor culture slightly increased from day 0 to day 6 and suddenly increased significantly from day 6 to day 8. On the last two days of production, a sudden drp in microbial count was observed.

The optimum speed of the bioreactor was found to be 10 rpm one which gave the highest yield of cellulose. Further increase in speed did not have an effect on cellulose yield. Statistical analysis ($p = 0.05$) showed that speed has a significant effect on the pellicle thickness.

The bioreactor is indeed capable of producing nata de coco. The UPLB strain and the commercial formualtion of coconut milk medium are suitable for use in the bioreactor. Further experiments will have to be done to optimize and shorten the process.

**CHE 200212 JIMENEZ, Luis S. (PhD Chem. Eng'g.)**
**Microbial Degradation of Benzene and Toluene Vapors in a Fibrous-Bed Bioreactor. 2000**

A study was conducted to investigate the removal of benzene and toluene vapors from a synthetically prepared waste air stream through microbial degradation in a trickle-flow bioreactor packed with an exceptionally simple and inexpensive fibrous medium consisting of a coiled sheet of cotton terry cloth. The fibrous packing exhibited excellent

characteristics for interphase mass transfer and biofilm attachment such as high static liquid holdup, high porosity, large specific surface area and high moisture retention capacity, maintained its structural integrity even after more than a year of continuous bioreactor operation, and allowed simple and stable operation and ease of control of back pressure, liquid holdup, and flooding. Liquid phase residence time distribution analysis showed continuous liquid film flow through the fibrous bed without droplet formation, low to intermediate liquid dispersion, fairly uniform velocity profile and flow path, and no significant liquid channeling nor stagnation. Benzene and toluene removal from waste air streams, ascribed to biological degradation alone and not to some other mechanisms, progressed independently from each other. Pre-acclimatization, the presence of benzene-degrading species such as *Pseudomonas putida* and *P. fluorescens,* and the ideal environment (e.g., absorbent and porous packing) for microbial attachment and growth within the bioreactor resulted in rapid bioreactor startup of 3 days. The bioreactor performed best with aqueous medium recycle at a rate just enough to maintain a wet biofilm (~ 1.43L/h) due to high gas-liquid mass transfer area and low mass transport resistance of thin liquid film, and partial wetting of the packing. Excess biomass was controlled by limiting the amount of $NH_4^+$-N in the aqueous recycle medium or by manually removing the packing from the bioreactor, scraping it free of excess biomass, and washing in water. The bioreactor was able to recover quickly from transient conditions such as a very low pH of 3, total depletion of $NH_4^+$-N in the aqueous recycle medium, and cleaning. During treatment of an air stream containing 1:5 (by volume) toluene/benzene mixed vapors, the bioreactor achieved elimination capacities for toluene and benzene of 25.8 g/$m^3$-h (98% removal) and 79.2 g/$m^3$-h (99.7% removal), respectively, at 1.39 min empty bed gas contact time and 1.43 L/h aqueous medium recycle rate.

**CHE 199913 KAAMIÑO, Maria Sheila B. (MS Chem. Eng'g.)**
**Parametric Evaluation of Cellulose Biosynthesis by WLB Strain Acetobacter Xylinum. 1999**

WLB strain, a local mutant strain *Acetobacter xylinum* produced 259.68% cellulose more than the existing *Acetobacter xylinum* strain (wild strain) of the Department of Science and Technology (DOST) in traditional surface culture method using coconut milk medium. The cellulose

produced by the WLB strain was of light cream color compared to the dark cream cellulose of the DOST strain.

Cellulose production was optimum at pH 4.5. Aseptic cultures yielded more cellulose than non-aseptic cultures as suggested by the thicker and heavier dry weight of aseptically produced cellulose. Shaking of cultures at 200 rpm for 12 hours daily for 10 days did not increase the yield of cellulose. Shaking of cultures however, disturbed the layered growth of cellulose. Less gluconic acid concentration was observed in the fermentation medium of the WLB strain. This suggested that the WLB strain utilized the supplied nutrients towards cellulose formation rather than towards gluconic acid production.

The spent medium of the WLB strain which was left undisturbed still effected a yield of 95.58% of the cellulose produced by the fresh medium. Whereas, the cellulose collected in the spent medium inoculated by the DOST strain is only 29.59% of the cellulose produced in the fresh medium. The discs of cellulose produced by the DOST strain contained holes in them. The spent media of both the WLB and DOST *Acetobacter xylinum* were not rejuvenated by fresh source of nutrients.

**CHE 200214 MATEO, Antonio L., Jr. (PhD Chem. Eng'g.)**
**A Study of the Effects of Carbon Chain Length of Alkyl Trimethyl Ammonium Chloride Surfactants on Fluid Drag Reduction. 2002**

Experimental studies on the effects of carbon chain length of cationic surfactants on fluid drag reduction, rheology and microstructures were conducted. Different carbon chain lengths of alkyl trimethylammonum chloride $C_nTAC$ (n=14, 15, 16, 17, 18) surfactants were used, and t heir corresponding surfactant solutions were compared relative to their drag reduction efficiencies, effective-drag-reduction-temperature ranges, optical properties, shear and extensional viscosities, viscoelastic behavior and micellar microstructures. The concentration ratio of $C_nTAC$ surfactant to the 3-chlorobenzoate counterion was kept constant (5mM $C_nTAC$/12.5mM 3-chlorobenzoate). The drag reducing properties of the odd-chained surfactants, $C_{15}TAC$ and $C_{17}TAC$, are the first measurements done for this type of surfactant-counterion system. An increasing trend in drag reduction efficiency and in drag-reduction-effective-temperature limit with respect to alkyl chain lengths was

observed. Turbidity measurements showed that Krafft temperature coincided with the lower-effective-temperature limit of drag reduction at 40 nephelometric turbidity units (NTU). Shear viscosity measurements revealed different fluid characteristics of $C_n$TAC systems at increasing strain rates. Shorter-chained surfactant systems behaved more like Newtonian liquids while the longer-chained amphiphiles exhibited non-Newtonian character. High extensional viscosities were observed in all surfactant solutions within the effective temperature range of drag reduction. At high strain rates, $C_n$TAC systems exhibited Trouton ratio (extensional viscosity to shear viscosity ratio) magnitudes greater than those of Newtonian fluids. Recoil and viscoelasticity were manifested by longer-chained surfactant systems at a particular drag reducing temperature. Swirl-decay-times (SDT) of shorter-chained surfactant systems were not detected by conventional or manual swirling methods. Zero first-normal-stress-difference coefficients. ($N_1$) were acquired at increasing shear rate under ambient temperature condition. Clear solutions of $C_n$TAC systems, at effective drag-reduction temperature range, revealed threadlike micellar network microstructures through cryogenic-transmission-electron-microscopy (cryo-TEM) technique. Vesicles and spheres were found to be present in $C_n$TAC systems with low drag reduction efficiencies. The cryo-TEM images of threadlike structures in shorter-chained surfactant systems validated the notion that Newtonian fluids could also be drag reducing at certain temperature range.

**CHE 199815 OME, Santos V., Jr. (MS Chem. Eng'g.)**
**Treatment of Fish Processing Waste Water in UASB Reactor Regarding Fat and Chloride Levels. 1998**

The feasibility of using UASB reactor for the treatment of fish processing waste waters of different fat and chloride levels was determined in this study. Fish waste water (3 – 4g $COD.1^{-1}$) was prepared from homogenized raw tuna and sardines to obtain mixtures similar to untreated fish canning waste water. The COD removal in treating high-fat waste water (i.e. fat-COD is 45 – 47% of total COD) was 87 – 97%. About 65% of the removed COD is converted to methane and the rest (about 35%) is removed as floating solids. The COD removed in treating low-fat waste water (i.e. fat-COD is 5 – 9% of total COD) is 74 – 89% of the influent total COD. Of the removed COD, 76 – 80% was converted to

methane. The hydrolysed COD in the low-fat fist waste water without chloride and the high-fat waste water is about 76% and 57%, respectively, of the influent total COD. In the treatment of high-fat waste water, the degradation of fats is rate-limiting. Chlorides inhibited the methane formation during the early stage of the UASB reactor run but methane production increased in the later stage indicating that sludge adaptation to high chloride level is possible.

**CHE 199416 PALACA, Ruena L. (MS Chem. Eng'g.)**
**Octacosanol from Ricebran Wax Lipase Method. 1994**

The sample used in this study is ricebran wax from Japan. Before hydrolysis, its chemical constants and the activity of lipase from *Pseudomonas Flourescens* biotype 1 were determined. Ricebran wax was hydrolyzed afterwhich, the reaction ratio is calculated. The condition which gave the highest reaction ratio is considered the best condition for the enzymatic hydrolysis of ricebran wax. After hydrolysis, the products were separated and the alcohols were analyzed by Gas Chromatograph using Triacontanol as standard. To increase the concentration of the desired product which is Octacosanol, the alcohol was crystallized. In the process of Crystallization, three solvents were used and results show that octacosanol crystallizes best in acetone. Triacontanol and Octacosanol were identified by Gas Chromatography-Mass Spectrometry.

**CHE 200117 PROMENTILLA, Michael Angelo B. (MS Chem. Eng'g.)**
**An Evaluation of Landfill Disposal of Asbestos-Containing Waste and Geothermal Residues Within a Risk Assessment Framework. 2001**

The public perception of risks relating to wasted disposal facility appears to reflect general societal anxieties and fears, which may not have reasonable basis. A three-tier risk assessment study was therefore conducted to evalaute the landfill disposal of asbestos-containing waste (ACW) and geothermal residues. The first tier involved hazard identification and toxicity assessment to assess the intrinsic hazard posed by the waste in the landfill. The second tier involved the development of a conceptual site model (CSM) ad a qualitative exposure analysis to identify

credible and potentially significant pathways that may arise from landfill disposal of the waste. In addition, the disposal and family-farm exposure scenario were defined to represent a hypothetical landfill for ACW and geothermal residues. Finally, the third tier involved pathway analysis and a risk assessment modeling using RESRAD-Chem's computer simulation to assess the chronic exposure and health effects arising from landfill disposal of geothermal residues.

Results from stereomicroscopic and petrographic observation indicate that the dominant asbestiform phase in the samples suspected as asbestos-containing waste is chrysotile, which is less toxic compared to amphibole asbestos (crocidolite and asbestos). The chrysotile fibers are tightly bound in the matrix of volumetrically dominant calcite as indicated in the X-ray diffraction analysis. Hence, relatively 'low' risk can be associated to landfill disposal of ACW since there is a minimal chance of releasing the fibers.

The identified chemicals of potential concern from geothermal residues are arsenic (As), cadium (Cd), chromium (Cr), and lead (Pb) based from the evaluation of secondary data. Based from RESRAD-Chem simulation, the significant contribution from water-independent pathways to the hazard or risk occurs at the early stage of simulation (post-closure period) while that of water-dependent pathways occurs 260 years after the post-closure period. From component pathway analysis, the critical environmental pathway is the plant uptake of the contaminant from contaminated zone (for the case of water-independent pathway) and the subsurface migration of the contaminant to the groundwater (for the case of water dependent pathway). The maximum cancer risk ($9.78 \times 10^{-4}$ due to As exposure) and hazard index (8.38 due to Cd exposure) exceeded the acceptable level ($10^{-4}$ to $10^{-6}$ for cancer risk, 1 for hazard index) within the timeframe of 100 years. For a timeframe of 1000 years, the maximum cancer risk ($3.61 \times 10^{-1}$ due to As exposure) and hazard index ($1.60 \times 10^{3}$ due to As exposure) also exceeded the acceptable level. There is a 'medium to high' but manageable risk that can be associated from landfill disposal of geothermal residues because of considerable pollution potential impact of leachate on soil and groundwater quality. Results from sensitivity analysis have identified the input parameters that have the most influence on the time of peak risk, and cancer risk contributed by water-dependent and water-independent pathway.

**CHE 200018 ROMERO, Carmela Y. (MS Chem. Eng'g.)**
**Treatment of Coconut Processing Wastewater Using an Upflow Anaerobic Sludge Blanket (UASB) Reactor. 2000**

The feasibility of treating coconut processing wastewater using an upflow anaerobic sludge blanket (UASB) reactor at ambient temperature (27°C) was investigated in this study. A laboratory-scale reactor was started-up and fed continuously with wastewater collected from three coconut processing industries.

The effect of pre-treatment and organic loading rate (OLR) on reactor performance was determined by dividing the experimental run into two phases: phase I – reactor operation without wastewater pre-treatment and phase II – reactor operation at different OLRs.

Without pre-treatment of the influent, average COD removal efficiencies of 40%, average methane production rate of 0.73g $COD_{methane}.L^{-1}.d^{-1}$ and low pH levels of ca. 3 to 6 in the effluent were observed. In phase II, COD removal efficiencies of about 90%, BOD removal of 70%, FOG removal of 82% were obtained at operating parameters of upflow velocity 0.2 $m.hr^{-1}$, organic loading rate of 12 g $COD.L^{-1}.d^{-1.}$ On the average, about 60% of the COD removed is converted to methane and the rest (about 40%) is removed as floating solids.

The adsorption of fats, and grease on sludge particles threatened the stability of the reactor and high levels of FOG resulted in the eventual wash-out of a large quantity of sludge. Thus, pre-removal of these particles before treatment in the UASB reactor is recommended.

**CHE 199919 SAN NICOLAS, Ellen C. (PhD Chem. Eng'g.)**
**An Extractive Fermentation Process for Production of Acetate from Lactose. 1999**

An acetic acid extractive fermentation process was designed and presented in this research. Two hollow-fiber membrane contactors were used: one for the stripping and regeneration of solvent and the other for the recovery of acetate from a mixture of lactate and acetate in the fermentation broth obtained from a two-step fermentation process of

lactose. An amine-based extraction was applied using 7% Adogen 283 in 2-octanol as the solvent. A fermentation kinetic study was also conducted for the two microorganisms *Lactococcus lactis* and *Clostridium formicoaceticum* to find a suitable operating condition f or a biological conversion that would be use in the extractive fermentation process.

The production of acetate by conventional fermentation technologies is limited due to a low reactor productivity, a low product yield, and a low product concentration due to product inhibition. Besides the very costly and energy-intensive downstream processing, finding a biocompatible solvent, i.e., a solvent that is less toxic to cells, and yet, with a high distribution coefficient ($K_d$) is another major drawback in the recovery of a product of fermentation. Furthermore, an optimum pH that works best both for fermentation and extraction processes is difficult to establish.

In this work, an extractive fermentation process for the production of acetate was developed to overcome the above-mentioned problems. A two-step fermentation process was employed, i.e., converting the lactic acid using *Clostridium formicoaceticum.* These two bacteria were immobilized in a fibrous bed using a cotton matrix supported by a stainless steel mesh.

A hollow-fiber membrane extractor was used to extract acetic acid from a very dilute fermentation broth. Another unit was used for a back-extraction to strip off the acid product while simultaneously regenerating the solvent for reuse. Because of an in situ recovery, the product inhibition was at least reduced, if not totally eliminated. Adogen 283 and 2-octanol were used as the extractant and the diluent, respectively. In the experiment using suspended cells, 7% Adogen 283 in 2-octanol was found to be non-toxic to either of the two bacteria *(Lactococcus lactis* and *Clostridium formicoaceticum)*. Beyond this concentration, the cells cannot survive any more and the fermentation did not proceed. Therefore, to reduce the toxicity caused by the water-soluble part of the solvent and the accidental breakthrough in the membrane, this solvent concentration was also used in the extractive fermentation experiment. The diluent was found to enhance the extraction ability of the extractant by improving the stability of the acid-amine complex in the organic phase, by providing solvation, and at the same time by reducing the toxicity caused by the pure extractant. Since the extraction was more efficient at a lower pH, the lactic acid produced from the first fermentation step was used to acidify the acetic acid in the second step.

A membrane-based phase contact used the static phase interfaces surfaces instead of the dynamic phase interfaces in mixing and settling. The high volumetric specific surface of the hollow-fiber membrane cartridge can give much higher mass transfer efficiency in type of phase contact. Also, the hollow-fiber membrane contactor was dispersion-free. The solvent toxicity was mitigated not only because the cells were immobilized but also there was no direct contact between the cells and the solvent since the design of the contactor provided the aqueous feed to be contained in the shell side while the solvent flowed through the tube.

From the results presented in Chapter 3 for a mixed-culture fermentation without in situ extraction and in Chapter 6 for an extractive fermentation, the reactor productivity increased by about 300% for the system containing 1.5% (w/v) sodium acetate as compared to the mixed-culture fermentation without in situ extraction. Furthermore, the increase in the reactor productivity for the same system was even higher, about seven times, as compared to a fed-batch fermentation without extraction. The addition of a dissociate acid was used as the strategy to promote the extraction of the acid product while raising the fermentation pH.

**CHE 199920 SENADOR, Antonio E., Jr. (MS Chem. Eng'g.)**
**An Investigation on the Use of Alternative Shapes to Determine the Applicable Strain Energy Function for Nearly-Incompressible Hyperelastic Materials. 1999**

Different assumptions on the nature of the mechanism involved in the deformation of hyperelastic materials have led to a number of different proposals for the functional form of the strain energy function. The proponents of each form employed different methods to fit their function on the experimental data, and they used different measures to assess the capability of these fitted models to predict the material behavior in other deformation modes. This investigation process another measure for assessment, which would subsequently lead to the selection of the best strain energy function to represent the actual material behavior.

The deformation of the sheet-with-hole and trapezoidal-sheet geometries were modelled in the ANSYS v5.0a finite-element program, using the James-Green-Simpson [1975] data as source of the material parameters. From the result of the simulation, (1) the ability of these two

geometries to bring out the differences between the functional forms of the strain energy function was assessed; (2) some criteria for the selection of another candidate geometry were pointed out; (3) the applicability of the finite-element method to simulate the test, as well as the weaknesses of the formulation in ANSYS, were examined; and (4) a general procedure for the use of the alternative geometries to select the most suitable strain energy function form was laid out. However, since only numerical simulations were done, actual experiments that will use the results of this study as guide were recommended to be performed in the future.

**CHE 200221 TABAGO, Elejiah D. (MS Chem. Eng'g.)**
**Decomposition Rates of Reducing Sugars in Sticky Cotton Using $NH_4OH$, $NH_4NO_3$, and *Saccharomyces Cerevisiae.* 2002**

The applicability of the sugar decomposition treatments in lowering the level of sugar content in sticky cotton was investigated. The microorganisms present in the cotton were identified and quantified. The sugar decomposition rates using $NH_4OH$, $NH_4NO_3$, Saccharomyces cerevisiae (baking yeast) were determined under 'anaerobic' condition. $NH_4OH$, $NH_4NO_3$, served as nitrogen source for the microorganisms already present in the cotton. *Saccharomyces cerevisiae* served as inoculant to enhance sugar decomposition in the cotton. *Saccharomyces cerevisiae* can decompose sugars both under aerobic conditions (via oxidative process) and anaerobic conditions (via fermentative process). Effect of the treatment on the strength and color of the fiber were also evaluated.

The study showed that 'anaerobic' condition was effective in decomposing sugars in sticky cotton than the aerobic condition at ambient room temperature and humidity. The sugar decomposition rate in cotton under 'anaerobic' condition is apparently first-order reaction kinetics, which indicates that the decomposition was a microbial mediated process attributed to activity of bacteria present in the cotton sample. The findings suggest that the role of bacteria, which was already present in the cotton in heavy growth is more important in the sugar decomposition process.

With 0.85% initial sugar content in raw cotton sample, the concentration decreased to 0.30% (critical level of sugars in cotton

acceptable for spinning) or less within six days a remarkable decrease in time compared to about 3 months or longer with usual aging process. Under aerobic condition, no remarkable decrease was observed.

The strength of cotton remained highly acceptable and that no significant change in the color was observed within six days that sugar content in the cotton reached 0.30% level.

**CHE 199322 TORRE, Margarita T. (MS Chem. Eng'g.)**
**The Corrosion of Reinforcing Bars in Concrete Using Pyroclastic Fall Deposits, i.e., Lahar, as Aggregates. 1993**

The corrosion of reinforcing bars in concrete using pyroclastic fall deposit (PFD), i.e. Lahar, as aggregate was studied. Electrochemical techniques were primarily used for the evaluation, however, characterization of the materials through identification of elemental composition, estimation of neutralization rates of the mortar and determination of the chloride penetration were also included in the investigation.

Results of the investigation showed that in 5% NaCl solution, the current density of embedded steel in PFD mortar is less than one-half of the current density of steel in natural riversand mortar. Furhtermore, in long term exposure to chloride contaiminated environment, the risk of steel corrosion is lower in a PFD concrete. In the thermodynamic or equilibrium state, steel behaves similarly in the two kinds of mortar.

The water-soluble chloride content of PFD is low compared to the considered threshold value.

The estimated ratio of carbonation/neutralization based on compressive strength showed that the rate in PFD is 1/1.7 times the rate of neutralization in a riversand mortar. Likewise, the depth of chloride penetration is also lower by about 50-60%.

**CHE 200023 VALENCIA, Sixto A. (PhD Chem. Eng'g.)**
**Color Removal of Basic and Reactive Dyes from Simulated Textile Wastewater by Adsorption on Corn Fiber and Biomediated System.**

The use of inexpensive adsorbing material such as fiber and

biomediated system to remove color from the simulated textile wastewater was explored. The biomediated system refers to the combined corn fiber and enriched culture of bacteria in a packed bed bioreactor. The research consists of three parts: (1) physical adsorption method using corn fiber as an adsorbent, (2) biological method using enriched culture of bacteria for color removal, and (3) combined treatment method using corn fiber and enriched culture of bacteria. The study used four types of dyes basic blue 54 (BB54), basic red 46 (BR46), reactive blue 52 (RB52) and reactive red 120 (RR120)).

The first part of the study evaluated the rates of adsorption and the shape of the equilibrium adsorption isotherms of the four dyes on corn fiber. The effects of different temperatures (28°C, 43°C, 60°C) and initial pH levels (5.0, 7.0, 9.0) were investigated. The rates of adsorption for the four dyes were found to vary in the order $r_{BB54}>r_{BR46}>r_{RB52}$ , $r_{RR120.}$ The samples of the equilibrium adsorption isotherms of the four dyes were best described by Langmuir adsorption isotherm model which indicate high adsorption rates of four dyes on corn fiber at low concentration range. The maximum adsorptive capacities $Q_{max}$ (mg/g) of corn fiber at an initial pH of 5.0 increased from 434.78, 196.08, 140, and 64.52 mg/g at 28°C to 454.54, 348.57, 166.67, and 102.04 mg/g at 60°C, for BB54, BR46, RB52, and RR120 dyes, respectively. At constant temperature of 28°C the maximum adsorptive capacities of corn fiber increased from 434,78, 196.08, 140, and 64.52 mg/g at pH of 5.0 to 555.56, 344.83, 166.67, and 102.04 mg/g at pH of 9.0, for BB54, BR46, RB52, and RR120 dyes, respectively. Results of the statistical analysis using t-test show that there is a significant difference between the effects of pH (5.0 and 9.0) and pH (7.0 and 9.0) at 5% level of significance. For the effects of temperature, only $Q_{max}$ at 28°C and 43°C were not significant, the rest of the combinations were significant.

The second part of the study used a biological method to remove color from the simulated textile wastewater. A mixture of bacteria, which grew in the experimental flasks during the conduct of the experiment was cultured, isolated, and purified. The pure culture of bacteria SV2 was identified and found to be very close to *Stenotrophomonas maltophilia* with similarity index of 83.8%. Its growth was evaluated using different substrates (e.g., glucose, ammonium acetate, propionic acid BB54, BR46 dye, BB54 dye plus corn fiber, and BR46 dye plus corn fiber). The effects of initial dye concentration on the percent color removal using an enriched culture of bacteria were investigated. An enriched culture of bacteria was

found to be efficient in removing the color of four dyes from the simulated textile wastewater. The time and extent of color removal depended on the volume ratio of dye-to-enriched culture of bacteria used.

The third part of the study investigated the combined use of corn fiber and enriched culture of bacteria i.e., biomediated system) in removing the color of four dyes from the simulated textile wastewater. The study determined if the time of treatment to achieve highest percent color removal could be reduced using the biomediated system. The percent color removal with respect to time was calculated. The time at which the biomediated system achieved 96%, 97%, 94%, and 86% color removal for BB54, BR46, RB52, and RR120 dyes were 1 day, 1.3 days, 7 days and 8 days, respectively.

**CHE 199424 YAPE, Erlinda O. (MS Chem. Eng'g.)**
**Extraction of Octacosanol from Rice Wax (Chemical Method). 1994**

Rice bran wax is composed mainly of testers which can be decomposed into two major components: the fatty alcohols and the fatty acids. These components could be obtained by alkali hydrolysis, otherwise known as saponification. The best operating condition in the production of alcohol was established and the fatty alcohol composition was identified by gas chromatography. Octacosanol, a component of the fatty alcohol present in the rice bran wax, was identified by GC-MS and GC. Octacosanol was found to be 13% of the fatty alcohols. The octacosanol was purified by recrystallization with acetone and hexane, with the combination of the two solvents as recrystallization solvents being more preferable.