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Summary

- Chemical/biochemical engineer, process scientist, team leader, project manager and educator with extensive industrial experience (including international experience) in flavors, food ingredients and specialty chemicals.
- Broad expertise in chemical/biochemical unit operations, including fermentation, filtration, centrifugation, membrane separations, distillation, extraction, adsorption, crystallization, drying, mixing, and process chemistry.
- Wide-ranging process engineering skill set, including process design, development and scale-up, equipment sizing and design, control systems, process simulation, economics and safety.

Industrial Experience

December 2013 – Present: *President, Gabelman Process Solutions, LLC* (West Chester, OH). Provide consulting services in process and bioprocess engineering to clients in flavors, food ingredients and specialty chemicals. Website: www.gabelmanps.com.

Selected accomplishments:

- Developed technology assessment, PFD, mass balance, capital cost estimate and utility consumption estimate for concentration and drying of bacterial biomass from a proposed fuel ethanol facility.
- Provided engineering support for design of the downstream purification line for production of natural blue color using algae. Responsibilities included equipment selection, sizing and design, P&ID development, general arrangement, and development of process metrics.
- Provided engineering support for design and construction of a vegetable processing facility. Responsibilities included equipment and piping layout, equipment specification and procurement, and development of P&ID and other engineering drawings.
- Managed a project to convert a warehouse into a liquid flavor production facility.
- Prepared a comprehensive evaluation of candidate technologies suitable for drying fruit purees and juice concentrates, along with go-forward recommendations. Technologies considered include spray, drum, freeze, refractive window, vacuum belt, microwave, radiofrequency, and infrared drying.

- Designed a skid-mounted pilot plant for recovery of organics from dilute aqueous streams using process chromatography, then led the team responsible for construction and startup.
- Optimized batch distillation processes for various chemicals using ChemCAD computer simulation. Demonstrated potential increases in capacity as high as 50%.
- Developed a spreadsheet model of heat transfer in 50L and 100L jacketed glass reactors. Using the model, assessed cooling requirements for highly exothermic reactions, and made recommendations regarding reactor design, operating conditions and thermostat selection.

2010 – May 2013: *Process Science Director*, **Firmenich** (Shanghai, China), a leading manufacturer of flavors and perfumes. Built a team of engineers and scientists to develop processes and technologies for extraction and purification of unique flavor and perfume building blocks from natural materials. Responsibilities included:

- Leadership of up to 10 engineers and scientists, including performance evaluation and career development.
- Development and execution of a technical program that supported the corporate strategy and business objectives.
- Annual operating budget.
- Capital budget for the entire Shanghai R&D group, including my team and others.
- Environmental, health and safety issues and compliance for the entire Shanghai R&D group, again including my team and others.

Selected team accomplishments:

- Developed a process for extraction and purification of a unique savory ingredient from a plant found in northern China. Interacted closely with flavorists, applications and business colleagues to ensure that the ingredient met cost and performance targets.
- Developed a cost-effective process for selective removal of pesticides and other agricultural residues from citrus oils using short path distillation or ion exchange, with minimal effect on sensory or other properties. This work will provide competitive advantage through increased sourcing flexibility and enhanced ability to meet customer requirements.
- Performed a comprehensive study of recovery of patchouli oil (a key perfume ingredient) from the patchouli plant by steam distillation. Carried out numerous pilot scale distillations to characterize the effects of operating variables and equipment configuration. Developed an in-depth understanding of the distillation process, along with a set of recommendations for the commercial partner that would improve their oil yield by as much as 9%.

1985 – 2010: **Givaudan Flavors Corporation** (Cincinnati, OH), the world's largest manufacturer of flavors and perfumes.

1997 – 2010: *Director, Process Technology*. Managed a team of engineers that developed process technology and supported Operations. Responsibilities included:

- Leadership of up to five process engineers, including performance evaluation and career development.
- Development and execution of a technical program that supported the corporate strategy and business objectives.
- Annual operating budget.

Selected team accomplishments:

- Proposed instrumentation and other upgrades for vacuum oven dryers used to dry savory flavors. Demonstrated experimentally that the proposed upgrades would reduce drying time by 33%. With project engineers and manufacturing personnel, designed, installed and started up the commercial system.
- Performed pilot testing on a continuous vacuum belt dryer, as a lower cost alternative to existing batch vacuum oven technology. Determined optimum drying conditions and scale-up parameters for numerous savory flavors.
- Investigated the application of conical basket centrifugation technology to replace the existing vertical basket unit for recovery of flavor capsules. Projected capacity increase was 120%.
- Designed and supervised the construction of a pilot plant equipped with a range of capabilities, including fermentation, membrane filtration, distillation, extraction, centrifugation, vessels to 1900-liter capacity, and computer control.
- With counterparts from other sites, developed and implemented a program for efficient delivery of process development and engineering support to manufacturing sites globally.
- Developed and implemented a membrane filtration process to remove wax from citrus oils. The process solved a longstanding problem by delivering treated oil that remains free of precipitated wax indefinitely. Co-inventor on patent.
- Developed adsorption technology to recover flavor from citrus aroma waters and apple essence. Collaborated with plant engineers to design and start up the commercial installation.
- Obtained laboratory and pilot plant data used to design a short path distillation unit for recovery of valuable ingredients from highly folded citrus oils.

Collaborated with manufacturing personnel on production equipment design and startup.

- Demonstrated the use of a reciprocating plate column as an alternative countercurrent extraction technology for recovery of flavor from orange oil. Advantages over the existing, more complex extraction equipment included less downtime for maintenance and reduced wax buildup.

1992 – 1997: *Manager, Engineering Sciences, Tastemaker* (Cincinnati, OH), a major supplier of flavors and flavor ingredients (purchased by Givaudan in 1997). Managed a team of engineers and technicians that provided process development and scale-up expertise to other R&D laboratories and the Cincinnati manufacturing site.

Selected team accomplishments:

- Developed a process for isolation of 99% pure natural butyric acid from fermentation broth. Downstream processing steps included liquid-liquid extraction and distillation. Worked with an outside contractor to design the required production equipment, then presented the entire package to a potential collaborator in China.
- Developed downstream purification methodology for other fermentation-derived flavors chemicals, including phenethyl alcohol and δ -decalactone, then scaled to manufacturing. Unit operations employed typically included crossflow membrane microfiltration and ultrafiltration, liquid-liquid extraction or hydrophobic resin adsorption/elution, and distillation.
- Developed a process for purification of *cis*-3-hexenol (precursor to numerous flavor esters) produced enzymatically using kale leaves, then worked with collaborator on scaleup. Unit operations included vibrating screen (to remove spent leaves), wiped film evaporation, hydrophobic resin adsorption/elution, and steam distillation.
- Led the effort to convert a 900-gallon storage tank to an aerobic fermenter, which required design and installation of heat transfer surface, an air sparger, an upgraded mixer, and modifications needed to maintain aseptic operation.
- Developed and scaled up numerous botanical extracts, including coffee, tea, and cocoa, using solvents such as ethanol and propylene glycol.
- Investigated and subsequently implemented spinning cone distillation technology for recovery of flavor from tea and various other botanicals. Project included initial testing on rented equipment, development of the equipment specifications and capital project appropriation request (with project engineer), startup, operator training, and product development.
- Served as liaison with an outside collaborator on investigation of dense carbon dioxide extraction using membrane contactors.

1985 – 1992: *Research Engineer, Hercules Incorporated* (Wilmington, DE), a manufacturer of specialty chemicals (whose flavor business became part of Tastemaker in 1992). Provided process development and scale-up expertise for fermentation-derived flavor chemicals, related food ingredients and paper chemicals. Supervised up to four technicians.

Selected accomplishments:

- Scaled up several fermentation processes, including butyric acid, propionic acid and acetaldehyde. Was inventor or co-inventor on three patents, including one for continuous butyric acid fermentation, which was demonstrated using a 60,000-liter fermenter.
- Developed and scaled up a process for producing crystalline rhamnose from a flavonoid precursor. Process involved acid hydrolysis, fermentation, membrane microfiltration and ultrafiltration, evaporation, ion exchange, activated carbon treatment, crystallization and drying. (This work was completed at Tastemaker.)
- Served as technical consultant on implementation of a fermentation process to remove chloropropanols from wet strength resins used in paper. Designed a continuous process that was later implemented in manufacturing, and developed a rotary vacuum precoat filtration process to clarify the fermented product.
- Provided process engineering support to an autolyzed yeast manufacturing site, including evaluation of alternative mixing systems and types of heat transfer surface for two 100,000-liter fermenters.
- Led the conversion of a 60,000-liter storage tank to an anaerobic fermenter, addressing challenges such as achieving and maintaining aseptic operation.

1984 – 1985: *Pilot Plant Manager, Engenics* (Menlo Park, CA), a startup bioprocess development company.

Selected accomplishments:

- Worked with an engineering design firm to develop the design and cost estimate for a fermentation pilot plant.
- Carried out laboratory and pilot scale development of a novel process for recovery of heat-stable lactic acid from fermentation broth.

1978 – 1984: *Process Engineer, Stauffer Chemical Company* (San Jose, CA), a manufacturer of specialty chemicals. Provided process engineering support for monosodium glutamate fermentation and downstream purification operations.

Selected accomplishments:

- Supervised the operation of a pilot ultrafiltration unit as a possible alternative to centrifugation, heat coagulation and rotary vacuum filtration to remove biomass and protein from fermentation broth.
- Responsible for startup of two falling film evaporators (capacity: 27,000 kg/hr each) that replaced several less efficient units, leading to a 50% reduction in energy usage.
- Performed extensive testing on rotary vacuum precoat filtration of centrifuged, heat treated fermentation broth (for removal of coagulated protein). Installed instrumentation and implemented operational changes that led to a marked improvement in filtration rate.
- Designed and implemented a control strategy for two vacuum pan crystallizers. Benefits included improved process consistency and yield.

Teaching Experience

2013 – 2018: Adjunct Assistant Professor, Department of Biomedical, Chemical and Environmental Engineering, **University of Cincinnati**.

2005 – 2009: Adjunct Assistant Professor, Department of Chemical and Materials Engineering, **University of Cincinnati**.

Education

Ph.D., Chemical Engineering, University of Cincinnati

Master of Chemical Engineering, University of Delaware

Bachelor of Science, Chemical Engineering, Cornell University

Publications, Patents and Presentations

List available upon request.

References

Provided upon request.