

Pilot Plant Services Group

Process Design & Development
Distillation, Extraction, VLE & LLE Testing

The **Koch Modular Process Systems, LLC** (KMPS) pilot plant facility in Houston, TX specializes in development and testing of mass transfer processes, including distillation, liquid-liquid extraction, absorption and stripping. Research findings from the pilot plant are then used for the design of separation systems. The systems are built to serve the Chemical, Pharmaceutical, Petrochemical, Biotech, Food and Flavor & Fragrance industries.

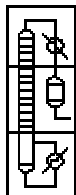
The pilot plant is used to test the processes as well as develop vapor-liquid and liquid-liquid equilibrium data. Accurate VLE and LLE data, fundamental for the design of mass transfer processes, is often not available in literature and must be developed prior to the design effort. KMPS also has a staff of experienced process engineers to design the test programs and then interpret the experimental data.

Our facility has more than 5,000 square feet of floor space and 42 ft of headroom. We have a strong commitment to safety in the workplace and are dedicated to being environmentally conscious. The pilot plant is equipped for both bench and pilot-scale testing of distillation, liquid-liquid extraction, absorption and stripping processes. In addition, an in-house analytical department supports the pilot tests. On-site analysis provides customers with on-the-spot feedback and reduces time spent in the pilot plant.



KMPS also designs and supplies complete full-scale separation equipment based on the pilot plant testing that carry a **Process Performance Guarantee**.

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KMPS

Koch Modular Process Systems, LLC. - Pilot Plant Services Group
45 Eisenhower Drive, Paramus, NJ 07652
Tel: 201-368-2929 Fax: 201-368-8989
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KEY FUNCTIONS

KMPS maintains a state-of-the-art pilot plant in Houston, Texas, dedicated to the mass transfer processes of distillation and liquid-liquid extraction. The pilot plant is extremely flexible, and equipment setups are customized for the particular problem at hand.

Tests are conducted in the smallest columns that will give reliable scale-up data. The advantage of using small columns is that it minimizes the amount of material required. Most tests require only 5 to 50 gallons of material. In addition, small equipment minimizes test time by reaching equilibrium conditions more rapidly.

Sufficient data for scale-up is routinely generated within one week of testing for each process step. With our many years of experience, KMPS has developed proven correlations that provide accurate scale-up from pilot to commercial size.

Analytical methods include gas chromatography, high-pressure liquid chromatography, spectrophotometry, wet chemistry and Karl Fischer Titration.

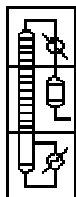
The final product of the pilot plant test is a report that contains the operating data necessary to allow KMPS to design and supply the commercial scale equipment with a Process Performance Guarantee.



OVERALL CAPABILITIES

- ◇ **Mass Transfer Operations**
 - Distillation (Batch or Continuous)
 - vacuum, azeotropic, extractive, reactive
 - Liquid-Liquid Extraction
 - simple, fractional, reactive
 - Absorption/Stripping
 - physical, reactive
- ◇ **Pilot Plant Tests are Performed to**
 - Confirm process feasibility
 - Optimize process operating conditions
 - Provide data for scale-up
- ◇ **Analytical Support**
 - GC
 - HPLC
 - Karl Fisher
 - Wet chemistry

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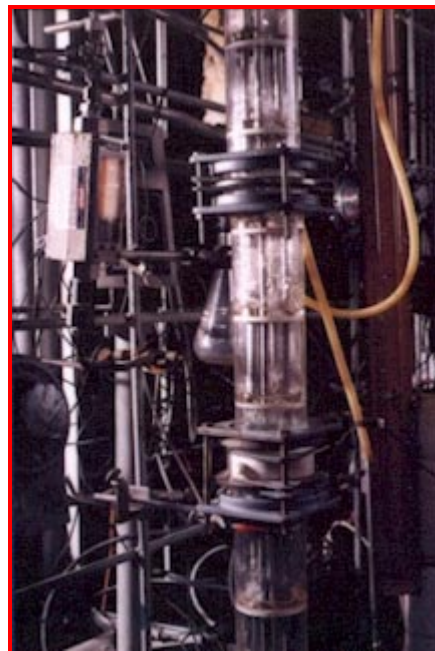
DISTILLATION

The column setup is customized for the application at hand. Column internals can be either trays or packing. Flanged column sections are used to provide maximum flexibility for arrangement of internals. Both stainless steel and glass sections can be used. Provisions can be made for multiple feed point locations, as well as vapor or liquid sidestream removal.

Reboilers can be kettle, thermosyphon, forced circulation or falling film, heated by steam, hot oils, or electricity. Alternatively, direct steam addition can be utilized.

Operating pressures 30 PSIG to 10 mmHg absolute are possible. Heat loss is minimized by means of heat tracing and insulation.

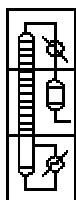
The pilot column is run over a range of operating conditions to measure separation performance and help determine optimum conditions. Other observations, such as operating stability, foaming, fouling, or thermal degradation, are also made and recorded. This type of data and information is extremely important for process scale-up.



DISTILLATION CAPABILITIES

- ◇ **Column Configurations**
 - Packed, Trays, Multiple Feeds, Sidestreams
 - Sizes range from 1" to 4" and up to 60 theoretical stages
- ◇ **Operating Pressures**
 - Pressure to 30 PSIG
 - Vacuum to 10 mmHG
- ◇ **Reboiler Types**
 - Kettle, Thermosyphon, Forced Circulation, Falling Film
- ◇ **Heat Sources**
 - Steam, Hot Oil, Electric

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EXTRACTION

KMPS offers a wide range of extraction columns, from static columns containing trays or packing, to agitated columns including Scheibel, Karr, Pulsed and rotating disc contactors (RDC).

Each of the columns has particular strengths and weaknesses, which must be taken into consideration to ensure the proper extraction device is selected. Often more than one type of extraction column is tested to help optimize performance.

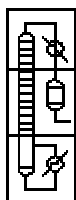
During the pilot tests, the columns are run over a wide range of operating conditions, and separation performance is measured. In addition, observations on droplet formation and dispersion, coalescence, interface control, entrainment, and emulsion tendencies are also made. Test data and observations are then used with KMPS proven scale-up correlations to arrive at the optimum extractor design.



EXTRACTION CAPABILITIES

- ◇ **Agitated Columns**
 - Karr™, Scheibel™, RDC, Pulsed
- ◇ **Static Columns**
 - Packing, Trays, SMVP™
- ◇ **Column Arrangements**
 - Simple, Fractional, Reactive

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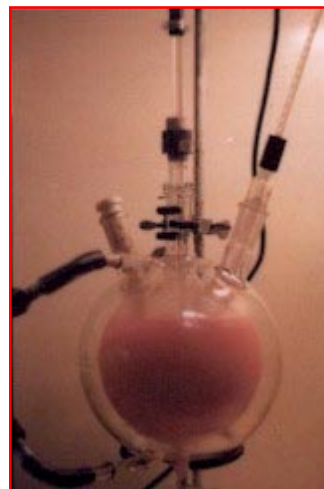
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VLE & LLE DEVELOPMENT

The first step in the process of pilot plant testing is often the development of vapor-liquid or liquid-liquid equilibrium data.

Due to the non-ideal nature of many of the systems encountered, experimental equilibrium data is required for design. If this data is not in literature it must be measured in the laboratory. Thus, it is often necessary to perform bench scale tests to fill gaps in the available data. LLE data for extraction and VLE data for distillation can be developed in our pilot facility. This data is then incorporated into computer models to optimize the process and establish operating conditions for the pilot plant tests to follow.

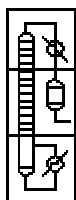
Also important during LLE and VLE tests are observations by KMPS's trained experts. For example, observations such as foaming or fouling often prove to be extremely valuable in avoiding potential operating problems in the pilot plant and/or commercial equipment.



OBJECTIVES

- ◇ **Data**
 - Vapor liquid equilibrium data (VLE)
 - Liquid-liquid equilibrium data (LLE)
 - Presence of any azeotropes or solutropes
 - Deviations from ideal behavior
- ◇ **Observations**
 - Foaming tendency
 - Fouling tendency
 - Degradation
 - Emulsion formation
 - Solids precipitation

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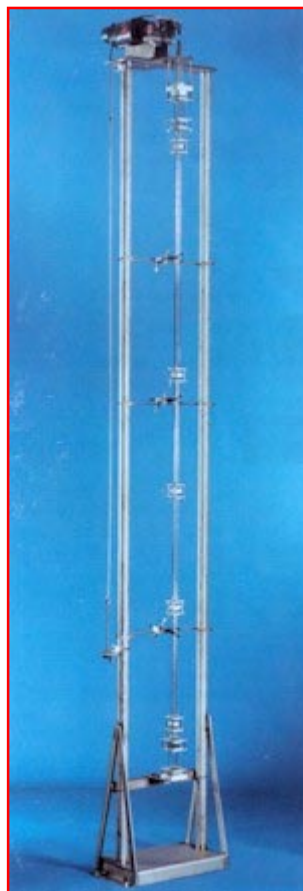
OTHER PRODUCTS

KMPS offers a broad range of laboratory and pilot plant liquid-liquid extraction equipment to assist you during feasibility studies, process development and equipment design stages of your project. The picture to the right shows a pilot scale extraction column.

Our equipment is available on either a sale or rental basis and includes the following:

- ◇ Laboratory scale extraction columns to screen solvents, evaluate feed variables and determine the feasibility of liquid-liquid extraction for specific applications.
- ◇ Small pilot scale columns (static and dynamic designs) to optimize the extraction parameters for scale up to commercial equipment.
- ◇ Large pilot columns for semi-works or small scale production facilities.
- ◇ Portable units, which can be rented for testing on site.

KMPS can provide trained service personnel to assist you in installing the pilot extraction column at your facility. KMPS is also available to help you set up an effective pilot plant test procedure and will work with you to interpret the test results and apply them to the design of your commercial column.



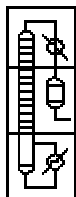
Agitated Columns

KMPS offers a number of agitated liquid-liquid extraction columns. These columns are normally provided with a borosilicate glass shell for observation of the process. Such observation is critical for optimization of the column performance. The standard designs are the 1" diameter Karr Reciprocating Plate Column and 3" diameter Scheibel and RDC columns.

Static Columns

KMPS also offers a 4" diameter static column packed with either SMV or SMVP extraction packing. This unique packing promotes good radial mixing while suppressing axial (back) mixing providing better plug flow characteristics and improving efficiency compared to random packing. The pilot column is offered with a glass shell (atmospheric pressure operation) and stainless steel shell (for operating at elevated pressures).

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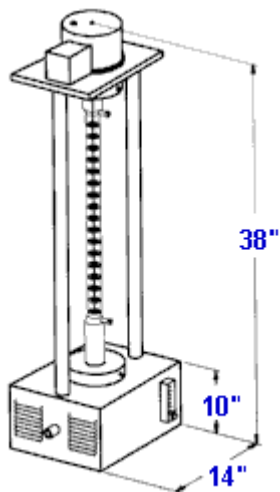
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Bench Top Karr Column



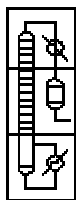
KMPS also offers a Bench Top Karr Column that consists of a 5/8" diameter glass column with a 24" plate stack height. Two (2) plate stack assemblies are included (316SS and Teflon perforated plates and spacers) with 1/2" plate spacing. An air motor is provided to regulate the agitation in the column. The unit comes in a stainless steel frame as shown in the sketch to the left. KMPS has demonstrated that up to 2.7 theoretical stages per foot of agitated height can be achieved with this unit.

Extraction Screening Unit



Sometimes the nature of process materials being handled prohibits testing at our pilot plant. In these cases, KMPS can deliver portable units and operating personnel to the plant for on site testing. Such as our portable Extraction Screening Unit (ESU) ideally suited for this purpose, see picture to the right. This unit consists of a 3" diameter x 12 - 18 stage, Scheibel Column with glass shell and air drive motor. Two stainless steel tanks with sight glasses and rotometers for flow control are mounted with the column onto a portable frame. Powered by air or nitrogen, it is ideal for use in hazardous areas.

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