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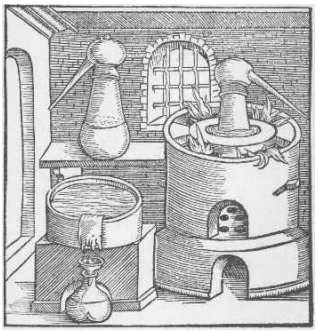

The "Chemistry Wing"

The project of an Integrated Didactic Lab of Chemical Engineering, Material Sciences and Pure & Applied Chemistry

In realisation at the Department of Material Science and Chemical Engineering

Reference

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Time scheduling

Start-up: Spring 2007

Civil works: started in September (2007)

Site delivery: planned by the end of December (2007)

Start of didactic activity: Spring 2008

Budget forseen

General services:	60,000.00 €
Furniture:	110,000.00 €
Equipment:	(see informative material attached)

Sections of the Lab

A) Chemical Engineering (Transport phenomena, Unit operations and Control)

B) Industrial chemistry, Instrumental analytical chemistry and Polymers processing

C) Material Sciences and Applied Chemistry

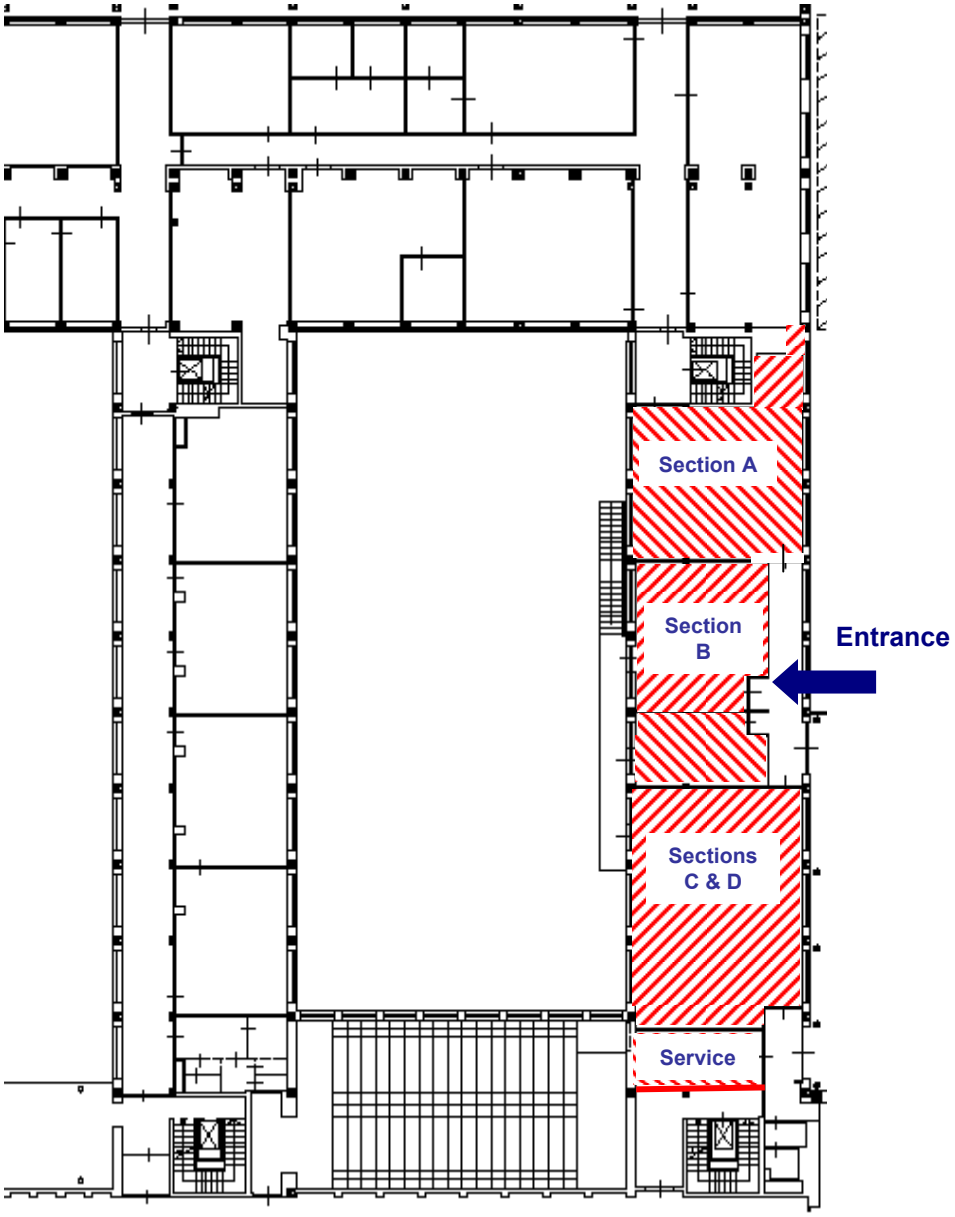
D) Base chemistry

Integrated with the Virtual Lab of Material Sciences and the Lab of Material Testing.

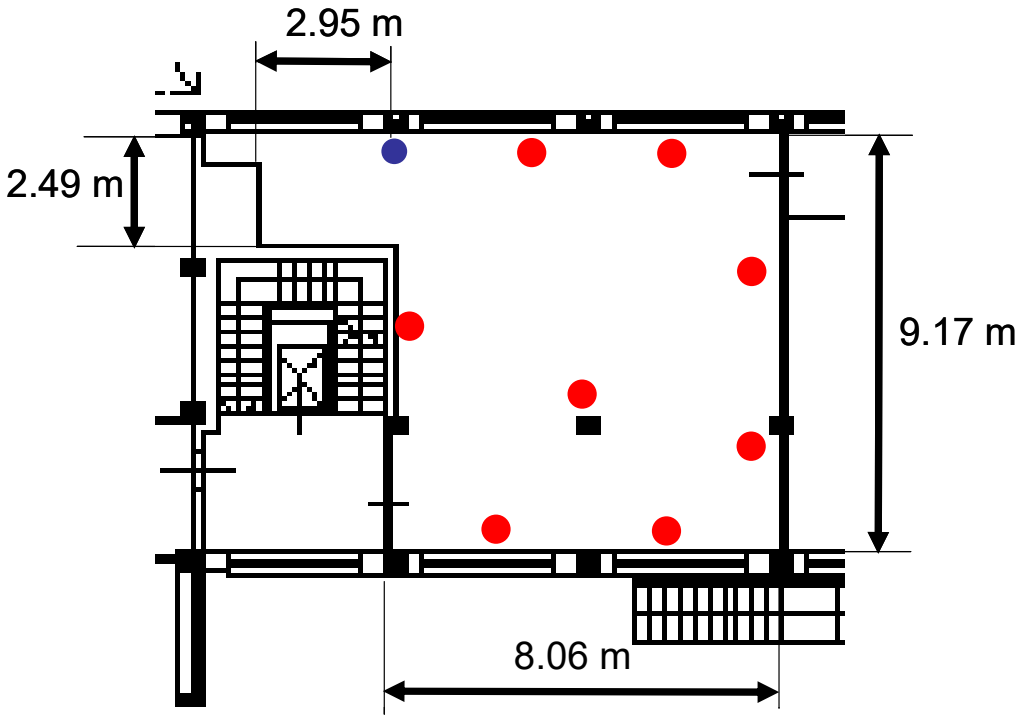
Dipartimento di Scienza dei Materiali e Ingegneria Chimica

Plant of the Laboratories

The Laboratories are located on the ground floor of the Department of Material Science and Chemical Engineering.



The plant of the Chemical Engineering section is the following:



In the Lab there are 8 working positions (indicated in the plant by a red circle) that are independent and, thus, simultaneously available for the students, plus a working position for the professor (indicated in the plant by a blue circle). The experiences are rotated during the semester due to space constrains.

A section of the Lab is devoted to Unit Operations, Chemical reactors and process control:

1. **Pressure drops in pipes and fittings** (curves, valves, changes of section): experimental validation of theoretical equations and calculation of the friction factor.
2. **Transport phenomena**: Investigation of the diffusion of matter in stagnant fluid.
3. **Heat exchange**: calculation of the heat exchange coefficient in various types of heat exchangers, namely air-water (radiator type), water-water (tube nest, concentric tube, plate type, operated either in cum-current or in counter-current mode) and water steam (tube nest type).
4. **Homogeneous chemical reactors and chemical kinetics**: investigation of the effect of the operating parameters (volume of reaction, residence time, temperature) on the performance of the CSTR (Continuous Stirred Tank

Reactor), of the cascade of CSTR, of the PFTR (Plug Flow Tubular Reactor) of the batch reactor. The fluid-dynamics of each device is also investigated by means of the RTDF (Residence Time Distribution Function). The same reactors can also be used to investigate the kinetic of simple reactions.

5. **Process control**: investigation of the closed-loop control of water temperature in a tank using either electronic or pneumatic controllers (with a Proportional-Integrative-Derivative action or with an On-off action).
6. **Bioreactor**: determination of the kinetics of biomass growth and product formation in batch Stirred Tank Reactor (bacteria and filamentous fungi). Macroscopic and microscopic observation of biomass morphology are performed, as well as the determination of biomass weight and product concentration.
7. **Mixing of fluid**: visualisation of the various fluid-dynamics regimes and calculation of the power required by the system as a function of the type of stirrer and of its velocity, also in presence of a gas flow and of a solid dispersion.
8. **Fixed and fluidised beds**: study of the pressure drops in a gas and in a liquid flowing trough a fixed bed; calculation of the minimum fluidisation velocity. Study of the homogeneous and of the bubbling fluidisation and of the spouted bed (minimum spouting velocity, height of the fountain).

A section of the Lab is devoted to Food Engineering. Simple and complex food are characterised and analysed to determine food properties or to detect possible patchiness due to food fraud or bad maintenance. Moreover, some food industries processes are reproduced on a laboratory scale and some reactions, that can take place during the processes themselves, are performed. The ffollowing experiences are planned:

1. **Sugars**: sucrose inversion, reducing power, process for pectin extraction, analysis for fruit juices characterization;
2. **Fats**: olive oil and oilseed analysis (characterization – acidity, viscosity, iodine number-, sophistications and bad maintenance detection), reaction for soap formation, emulsions formation and emulsifier agents effect;
3. **Milk and milk derivates**: milk analysis, cheese making, butter analysis.
4. **Wine**: Acidity measurement and sensorial analysis
5. **Chocolate**: measurement of rheological characteristics as a function of cacao content.

A revamping of the experience available is ongoing, with substitution of older equipment and acquisition of new experiences. We have planned also to equip the Lab with the following experiences:

1. **Distillation and absorption**: study of the influence of the operating parameters (heat duty, ratio) on the results (product flow rate and purity).

2. **Extraction**: study of solid/liquid and of liquid/liquid extraction using solvents with different volatility.
3. **Heat transfer**: study of the various mechanisms of heat transfer, namely conduction, convection and radiation including combined effects, non-steady state and measurement errors.
4. **Solid handling unit**: study of angle of repose, bulk density, sieving techniques, hopper discharge, comminution by a ball mill, solids mixing, cyclone operation, pneumatic conveying.
5. **Gal**-liquid absorption: investigation of fluid-dynamics and chemical adsoprtion tests. A column is actually available to be commissioned.
6. **Catalytic chemical reactors**: a three-phase trickle-bed is available to investigate the kinetics of the catalytic oxidation of fatty acid as well as the influence of the operating parameters on the performance of the system. Actually is not operating due to space constrains.

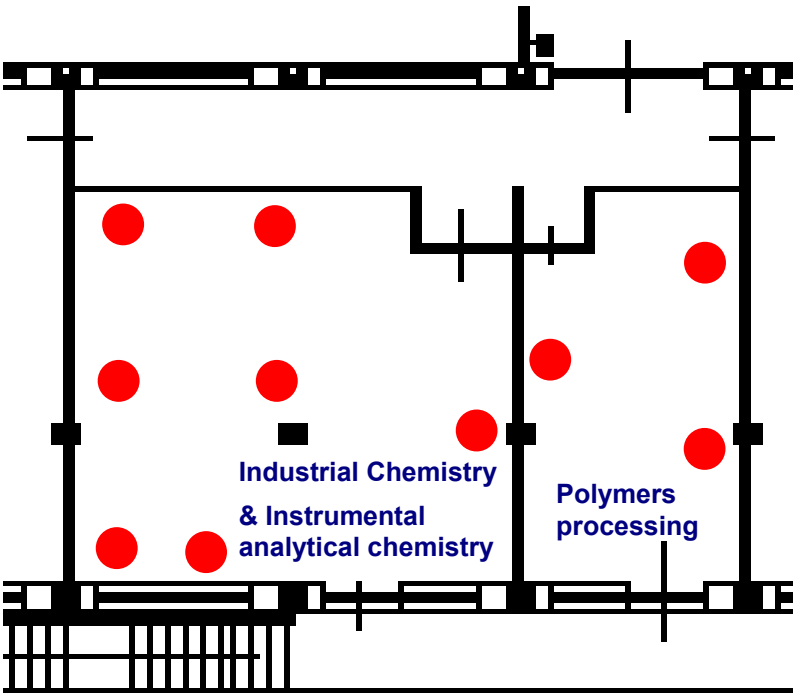
A section devoted to the Applied Thermodynamics and Heat transmission for the students of Chemical Engineering and of Material Engineering is also planned; the following experiences will be carried out in the Lab:

1. experimental determination of the liquid-vapour state diagram of some binary mixtures (benzene-toluene, water-ethanol, ethanol-ethylacetate) and of the composition of azeotropic mixtures at atmospheric pressure;
2. experimental determination of the state diagram of a mixture liquid-solid with formation of eutectic;
3. measure of the osmotic pressure for aqueous solutions containing electrolytes and non-electrolytes and comparison with an ideal solution.

The catalytic reactor and the bioreactor have been realised in the Department for research purposes and then forwarded to this Lab.

The homogeneous chemical reactors, as well as the unit for the study of the mixing of fluid and of fixed and fluidised beds have been designed and realised in the framework of a co-operation agreement between Didacta Italia and the Department of Material Science and Chemical Engineering, with the goal to get equipment much more suitable for High Level education.

The plant of the Industrial Chemistry, Instrumental analytical chemistry & Polymers Processing sections is the following:



The section of **Industrial Chemistry** is mainly dedicated to experiences about water analysis and treatment. Therefore the instrumentation is mainly aimed to carry out analytical operations as titrations, potentiometric measurements and spectrophotometric evaluations. Seven workplaces are available (indicated by a red circle in the plant) for seven groups of 2/3 students each (for a team of about 15-20 students). Each workplace is composed as it follows:

- pH-mVoltmeter (Hanna Instruments) equipped with glass, platinum and ion selective electrodes for silver and chlorides;
- personal computer with data transfer software;
- digital piston burette (Titronic Schott), micropipette, magnetic stirrer;
- common laboratory glassware.

The laboratory equipment consists also of a UV-Visible spectrophotometer (Thermo Electron) and two gaschromatographs (Varian and Carlo Erba, now Thermo Fisher

Scientific) for packed and capillary columns.

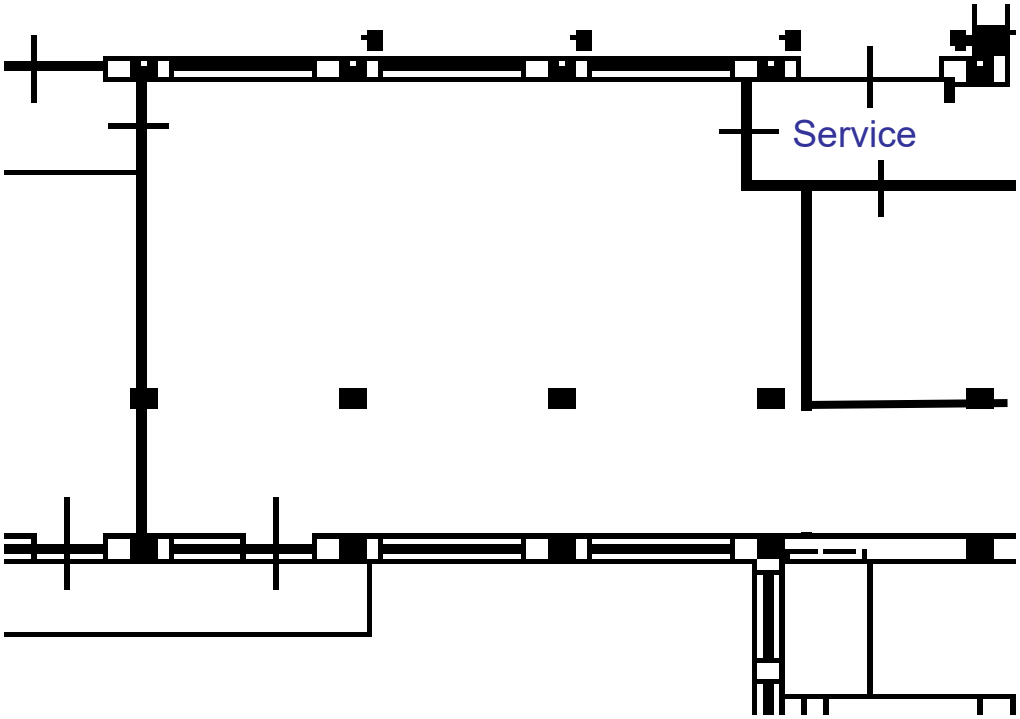
The section of Polymers processing is devoted to the following experiences:

1. **Molecular weight determination by viscosimeter measurements**: calibration curves will be obtained starting from known concentration polymer solutions. The Ostwald capillary will be used to calculate the intrinsic viscosity. The measurements will be performed into a thermostatic bath;
2. **UV-induce photopolymerization**: a UV lamp, with a shutter, will be used in order to do a UV induced polymerization of an epoxy resin.
3. **FT-IR investigation**: an FT-IR kinetic of a polymerization reaction willl be performed by using the FT-IR spectrophotometer ATI Mattson. The different spectra collected during different time will be evaluated and a conversion curve as a function of reaction time will be obtained;
4. **Thermal DSC-TGA experiments**: both DSC and TGA analysis will be performed by using a Mttler-Toledo Instrument interfaced with a computer able to follow on line the thermal analysis;
5. **Viscosimeter measurements**: a plate-to plate- viscosimeter will be used in order to build up viscosimeter curves and make rheological experiments on different oligomers;
6. **Melt-Flow Index determination**: different polymers, in the form of pellets, will be used and compared with respect their MFI, a very important values for technological employment of the polymers.

The students at the third year of the course of Materials Engineering will attend this Lab; the experiments will be carried out during all the semester, in parallel to the theoretical class. All the experiments will be performed in small groups of 3-4 people.

The equipments for DSC and TGA, the FT-IR spectrophotometer and the UV lamp are equipments normally used for research purposes. The plate-to plate- viscosimeter, the thermostatic bath for viscosity measurements and the system for measuring the melt flow index are required.

The plant of the Material Science and Applied Chemistry section and of the Base Chemistry sections is the following:



The activity of the laboratory of Base Chemistry started in October 1999. At the beginning it was attended only by students of the coursed of Chemical Engineering and of Material Engineering. In the following years, the possibility of making the experiments concerning Base Chemistry was given also to the students of other courses that requested it. Professors (or researchers) of chemistry followed the students on a voluntary basis. In the year 2005 the lab was opened to all students of the 1st College of Engineering, thus hosting about 1300 students that increased in the following years to 1800. It has to be noted that this chemistry lab is the most attended basic chemistry lab among all the Italian Colleges of Engineering. In the other colleges, generally, only virtual labs are used for a number of students lower than 1000. (data presented in AICIng06 congress held in Turin, September 2006).

The lab is opened every day from 8.30 to 13 and from 14 to 18.30 from October to December. Groups of 30 students, divided in little groups of 3 persons, directly make experiences in the lab. Some PhD students, graduated in chemistry or in chemical engineering, are involved as assistant personnel during the lab experiences (two people are always present at the same time).

The following experiments are carried out:

1. **Salt precipitation**: $Fe(OH)_3$, $BaSO_4$, $PbSO_4$ (the last one is also filtered, dried, and weighted to evaluate the obtained amounts)
2. **Calcimeter**: $CaCO_3$ + HCl reaction. The original amount of $CaCO_3$ is evaluated from the CO_2 volume.
3. **Gas Law**: verify of the V = kT relationship
4. **Tritation**: acid-base (HCl-NaOH) and redox ($FeSO_4$-$KMnO_4$) tritation
5. **pH measurement**: dilution of HCl solutions and hydrolysis of salts
6. **Daniell cell**: measurement of the intensity of the current and of the voltage in a Daniel cell;
7. **Water electrolysis**: electrolysis of acid solution with the measurement of H_2 and O_2 volumes;
8. **Redox reaction**: Cu in HCl e Cu in HNO_3;
9. **Chemical equilibrium**: verify of the principle of Le Chatelier using the reaction $Cu^{2+}_{(aq)} + 4Cl^{-}_{(aq)} \leftrightarrow CuCl4^{2-}_{(aq)reaction}$ as a case study.

Instrumentations were bought in the first years thanks to some funding (about 30 ML) provided by the administrations of the Chemical Engineering and Material Engineering courses. DISMIC provided financial support for the ordinary maintenance of the lab and for the PHmeters acquisition. Old instrumentations were recovered and some others equipments were forwarded by some research groups of DISMIC.

The present labs are actually barely sufficient for the current number of students enrolled. The contemporary attendance, in full safety, of 50 students assisted by two persons of the staff is possible, but for a very limited number of hours; thus the lab experience for the first year student has been severely reduced with respect to the original one. A proposal for new larger labs to be realised in the framework of the bew POLITO Masterplan has been submitted.

Moreover, we consider the possibility that this lab can also practically be attended by handicapped students. To this aim, the laboratory has been projected so that a wheelchair can move easily inside. We foresee to furnish this lab with benches without cabinets under them to permit the wheelchair to travel in the lab. Cabinets are foreseen only under one table on which supply materials will be stored. Some closets will be put out of the lab.

The lab is provided wit a hood for manipulation, and a little lab for technicians preparing solutions and materials required to carry out the experiments is also avilable.

Some experiences devoted to Applied Chemistry and Materials Technology can be exploitable in the frame of this part of the laboratory, such as:

1. Temporary and permanent hardness of waters

2. Low and high calorific values of liquid and gaseous fuels
3. Viscosity of lubricants
4. Calcimetry
5. Setting time of standard cement pastes
6. Granulometric analysis of aggregates for concrete