TLC vs GC vs HPLC

Thin Layer Chromatography (TLC)

Principle:

TLC separates compounds according to how strongly they attach to a thin adsorbent layer spread over a plate. As the solvent moves upward, each compound travels a different distance depending on its polarity and its ability to compete with the mobile phase for binding to the stationary surface.

Sensitivity:

The technique shows moderate sensitivity. Spots are usually detected under UV light or by spraying/color-developing reagents such as iodine vapor or ninhydrin.

Selectivity:

Selectivity is affected by both the nature of the stationary surface and the solvent system. Adjusting the polarity of the mobile phase can enhance or weaken separation efficiency.

Applications:

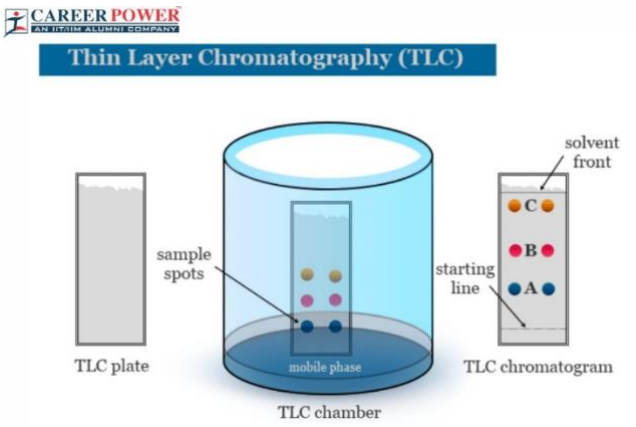
TLC is commonly used for quick checks, such as evaluating purity, comparing components in mixtures, and monitoring the progress of reactions. It works well for compounds that cannot evaporate easily or degrade with heat.

Advantages:

TLC is inexpensive, requires no advanced equipment, and allows many samples to be analyzed on a single plate. It is fast and straightforward.

Disadvantages:

The technique has limited quantitative value. Results may vary depending on the student's handling and interpretation. Sensitivity and resolution are also lower compared to modern chromatographic instruments.



Gas Chromatography (GC)

Principle:

GC separates compounds in the vapor phase. A gaseous mobile phase carries the sample through a heated column. Compounds distribute between the gas and the stationary phase depending on their volatility, boiling points, and interactions with the column material. Only volatile and thermally stable compounds can be analyzed.

Sensitivity:

GC offers very high sensitivity and can detect trace amounts. Several detectors can be used, including FID, TCD, ECD, NPD, and FPD, each specialized for certain classes of compounds.

Selectivity:

GC provides excellent selectivity, particularly when capillary columns are used. Temperature programming and controlled carrier gas flow allow very precise separations.

Applications:

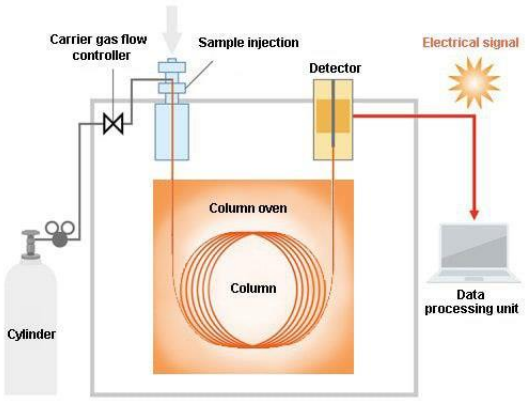
GC is widely used for analyzing volatile substances such as essential oils, organic solvents, environmental pollutants, and drugs. It is essential in forensic work and can identify compounds accurately when coupled with mass spectrometry (GC–MS).

Advantages:

The method provides outstanding resolution, sensitivity, and reproducibility. It is highly suitable for quantitative work, and analysis times are generally short.

Disadvantages:

A major limitation is that the sample must vaporize without decomposing. The equipment is costly and requires high-purity gases and regular maintenance. It is not suitable for large, non-volatile, or thermally unstable compounds.



High-Performance Liquid Chromatography (HPLC)

Principle

HPLC separates compounds based on their interaction with a liquid mobile phase and a densely packed stationary phase inside a high-pressure column.
The mobile phase is pushed through the column at high pressure, forcing analytes to migrate at different speeds depending on their polarity, solubility, and affinity for the stationary phase.

Sensitivity

HPLC provides high sensitivity, allowing detection of very small amounts of compounds.
Different detectors can be used such as UV, fluorescence, and electrochemical detectors, making the method suitable for a broad range of analytes.

Selectivity

Selectivity in HPLC is excellent and can be controlled by changing:
The polarity of the solvent
The pH of the mobile phase
The ionic strength
The type of stationary phase (e.g., C18)
This flexibility allows precise tailoring of the separation.

Applications

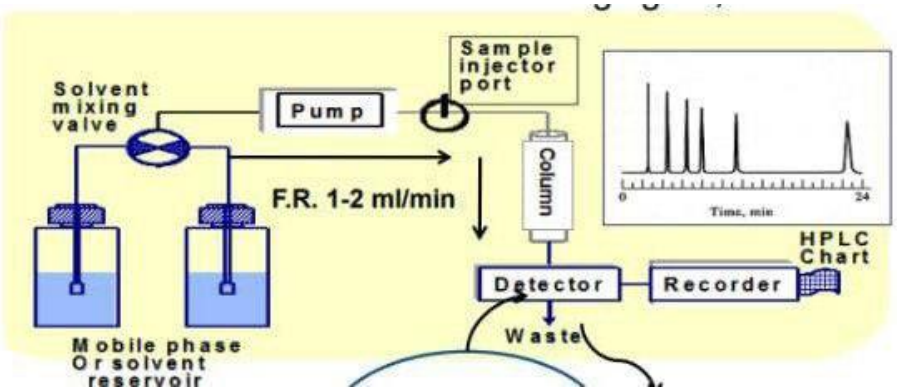
HPLC is widely used to analyze:
Pharmaceuticals (drug purity and dosage)
Biological fluids
Natural products and plant extracts
Food components and preservatives
Compounds that are not volatile or thermally stable
It is a major tool in quantitative chemical analysis.

Advantages

High accuracy and high resolution
Suitable for both qualitative and quantitative analysis
Can separate complex mixtures
Works with heat-sensitive and non-volatile compounds
Wide variety of columns and detectors available

Disadvantages

Expensive equipment and solvents
Requires regular maintenance and calibration
Sample preparation can be time-consuming
Consumables (columns, filters) can be costly



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