Unit 10 Ion Exchange and Solvent Extraction

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New words

- Cuprammonium **[,kju:prə'məuniəm]** 铜铵
- stripping 反萃['strɪpɪŋ]
- rayon 人造纤维['reɪɑːn]
- elution [ɪ'ljuːʃən] 解析，洗脱
- effluent ['efluənt] 流出液
- tantalum['tæntələm] 钽
- immiscible不混溶的 [ɪ'mɪsəbl]
- pulsation 脉冲[pʌl'seɪʃn]
- ion exchange离子交换
- solvent extraction溶剂萃取
- Cation exchanger **['kætaɪən]** 阳离子交换树脂
- Anion exchanger ['ænaɪən]阴离子交换树脂

New words

- amphoteric **exchangers** [ˌæmfə'terɪk]两性离子交换树脂
- proprietary [prə'praɪətəri]　专有的
- perforate 穿孔['pɜːrfəreɪt]
- chelating 螯合 ['kiːˌleɪt]
- niobium 铌 [naɪ'oʊbiəm]
- append 附加说明[ə'pend]
- kerosene 煤油['kerəsiːn]
- reversed [rɪ'vɜːst]逆向的
- sorption吸附 ['sɔːpʃən]
- resin[‘rezn]树脂
- phosphoric acid磷酸[fɒs'fɒrɪk]
- extractant [ɪks'træktənt]萃取剂
- brass industry黄铜工业
- solute [sɒ'ljuːt]溶质
- Feed solution料液
- raffinate ['ræfəˌneɪt]萃余液

New words

- Adsorption capacity [æd'sɔ:pʃən] [kə'pæsɪtɪ]吸附容量
- contaminant [kən'tæmɪnənt]污染物
- **platinum** ['plætɪnəm]铂，白金
- derivative [dɪ‘rɪvətɪv]衍生物
- Carrier ['kærɪə]载体
- **diesel** ['di:zl]柴油
- **gasoline** ['gæsəli:n]汽油
- uranium [ju'reɪniəm]铀
- vanadium [və'neɪdiəm]钒
- titanium **[tɪ'teɪniəm]** 钛
- zirconium [zɜ:r'koʊniəm]锆
- Counter current extraction逆流萃取
- Cross current extraction错流萃取

outline

- Ion exchange definition
- Ion exchange operation
- Solvent extraction operation
- Extractant requirements
- Solvent extraction application
  - Copper recovery
  - Uranium recovery

syntax

- Describe an operation including two steps
- Difference between process and operation
  - Process: a sequence of operations
  - Operation is termed as a series of steps, taken together, to achieve a consistent result
- With 的用法

01

Part one

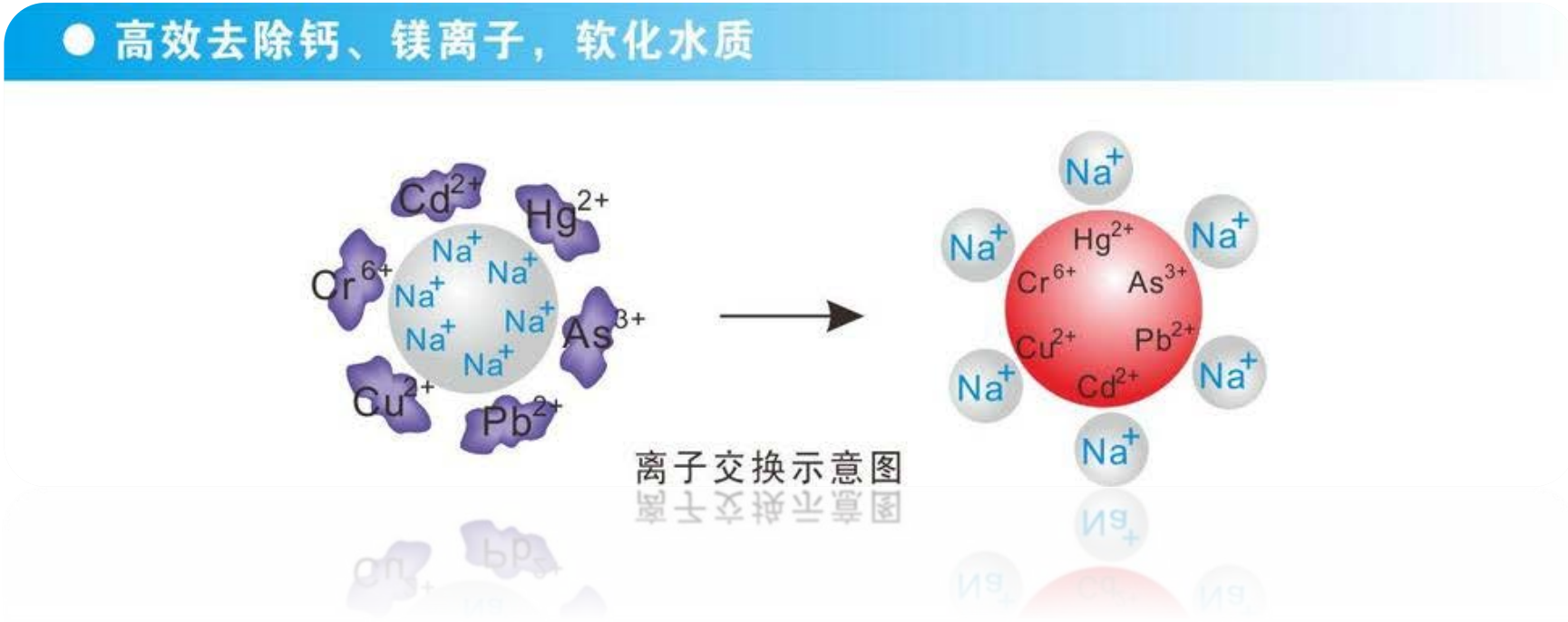
The definition of ion exchange and its application

Ion exchange can be defined as exchange of ions between a solution and a solid by which ions from the solution are taken up and retained by the solid which gives up an equivalent number of ions to the solution without any physical change in its structure.

离子交换的定义是,离子在溶液和固相之间进行交换，通过离子交换，溶液中的离子进入固相，而固相中又有等当量的离子进入溶液。固相的结构不发生任何变化。

Take up 占用，　retain保留

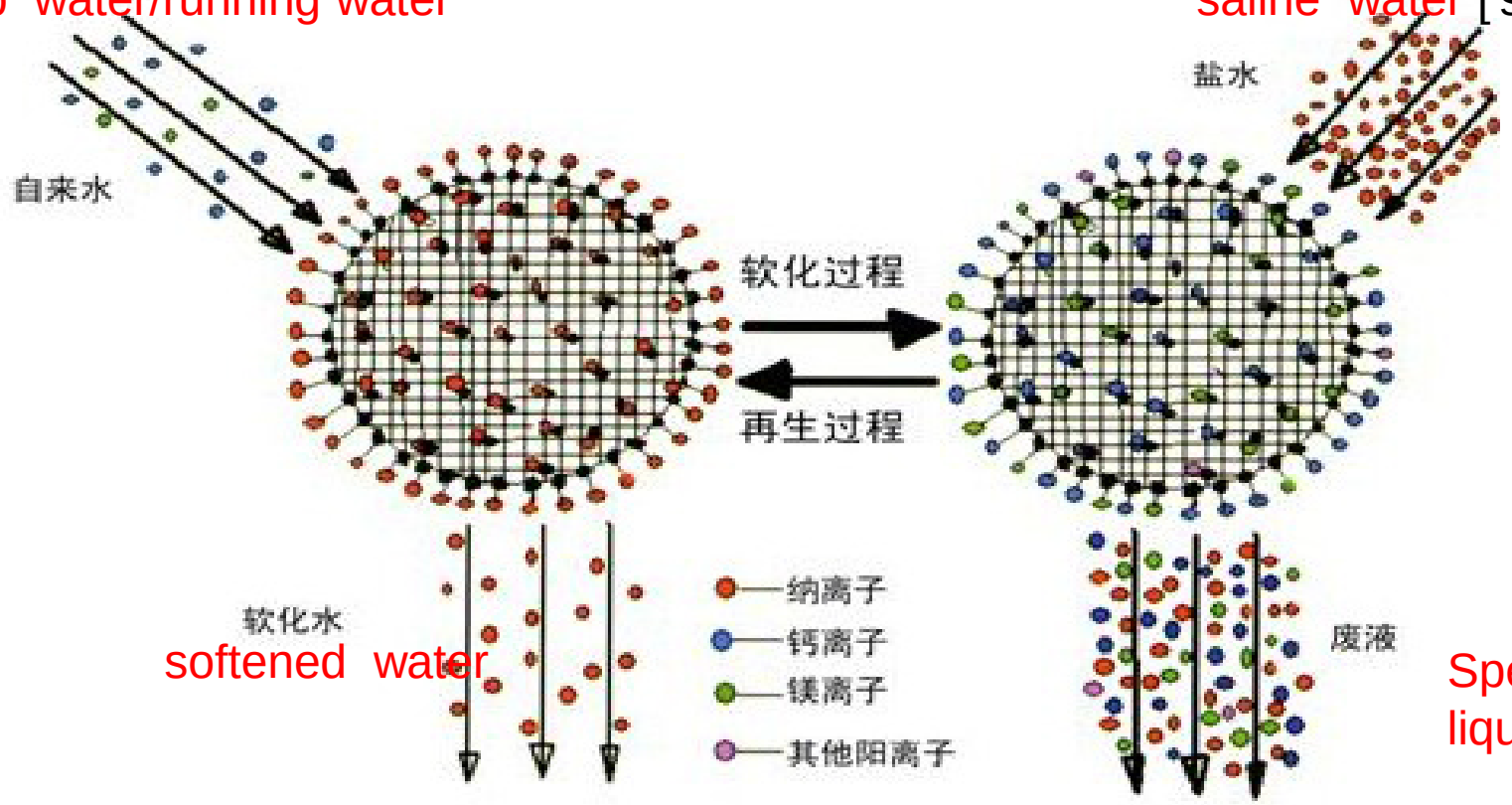
The first attempt to utilize ion exchange phenomena was in the field of water softening around 1906, using natural and synthetic（合成的） silicates(硅酸盐）.



离子交换

Tap water/running water

saline water ['selin]



The improved synthetic organic resins（树脂） greatly broadened the application potential for ion exchange processes due to their stability and high capacity.

The first attempts to apply ion exchange for metal recovery were in connection with recovery of copper from waste liquors of the cuprammonium(铜氨） rayon（人造丝） and brass industry, silver from photographic film manufacturing wastes, and chromium（铬） from electroplating（电镀） wastes.

brass industry黄铜业

Uranium（铀） was the first metal to be recovered from leach solutions by ion exchange on a large scale, and the great amount of research done in this field opened the doors to the wide possibilities of using ion exchange for recovering other metal from leach solutions.

The ion exchange process is especially useful in the treatment of very dilute solutions with metal ion concentration of 10 ppm or less. For solutions with metal ion（金属离子） concentration above 1% this method is generally not of value.

02

Part two

The main steps of ion exchange

Ion exchange operation consists of two steps:

1) Sorption（吸附）.

- The solution containing the metal values is passed through a bed of resin（树脂层）, whereby the metal ions to be recovered leave the aqueous phase and enter the resin phase.
- When the bed gets saturated（饱和） with the metal ion in the feed, the metal ion will appear in the effluent（污水；流出物）(break through), and therefore the flow of feed should be stopped.

当树脂层被溶液中的金属离子所饱和时，在流出液中就会出现金属离子，这时应该停止往树脂中加料

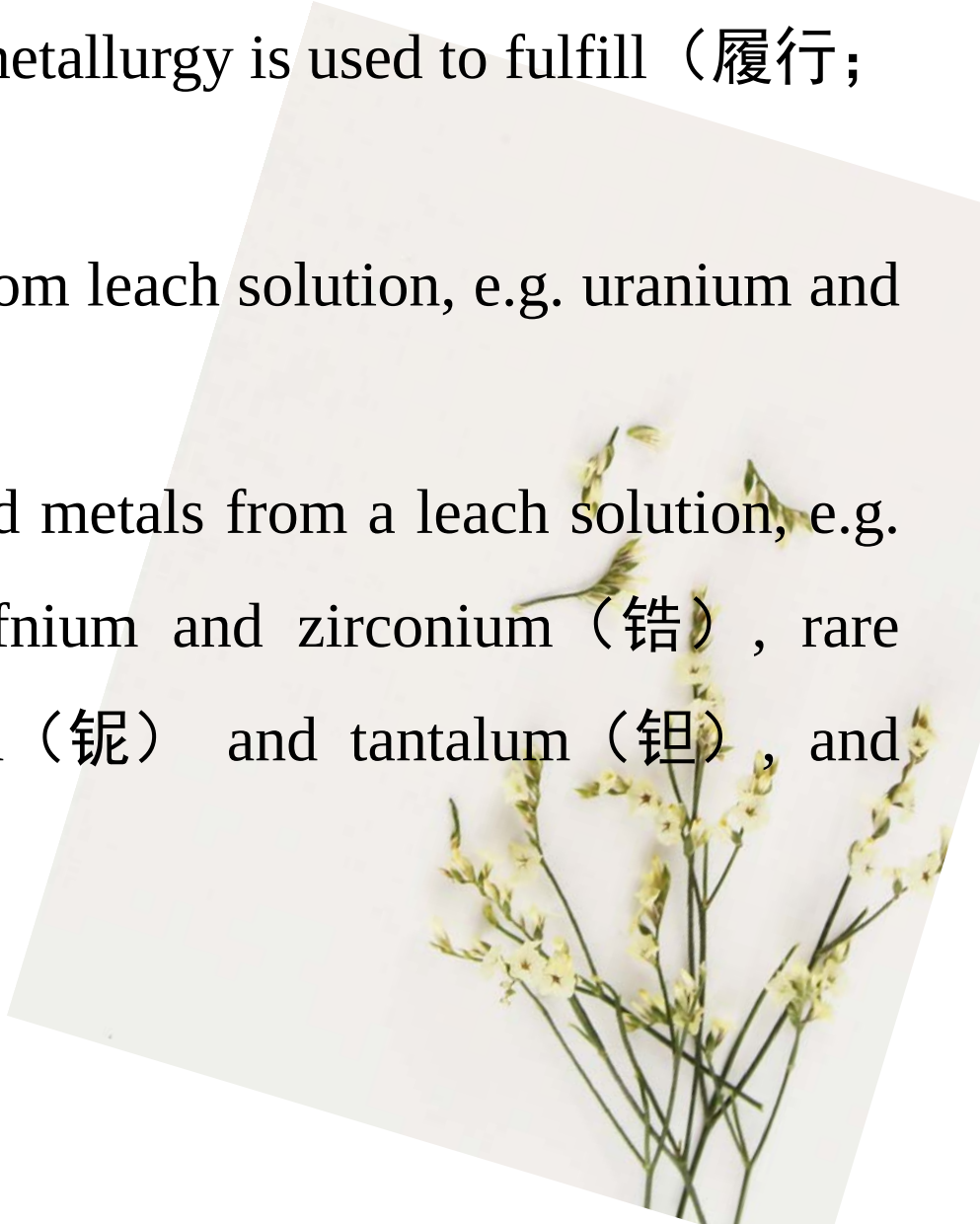
Break through 穿透

2）Elution（洗脱，解析）.

- Passing a small volume of a suitable solution that removes the metal ions completely from the resin. After each of these two operations, the bed is washed to remove loosely（松散地）absorbed ions.
- In this way a concentrated solution of pure metal ions is obtained which can be processed（处理；加工） further to recover the metal, and the resin is generated（使形成；发生） by washing for reuse（重新使用；再利用）.

Now ion exchange in extractive metallurgy is used to fulfill（履行；实现） the following purposes:

- 1) Recovery of metal values from leach solution, e.g. uranium and vanadium（钒）.
- 2) Separation of closely related metals from a leach solution, e.g. cobalt（钴） and nickel, hafnium and zirconium（锆）, rare earths,（稀土元素） niobium（铌） and tantalum（钽）, and the platinum metals.



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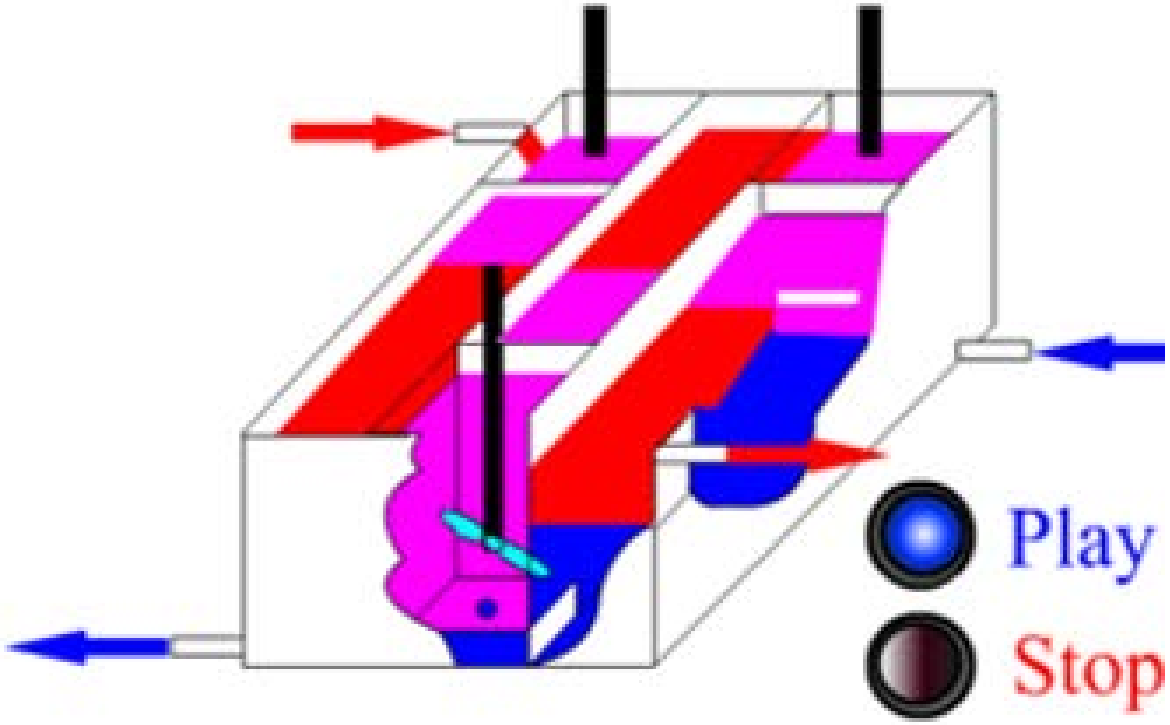
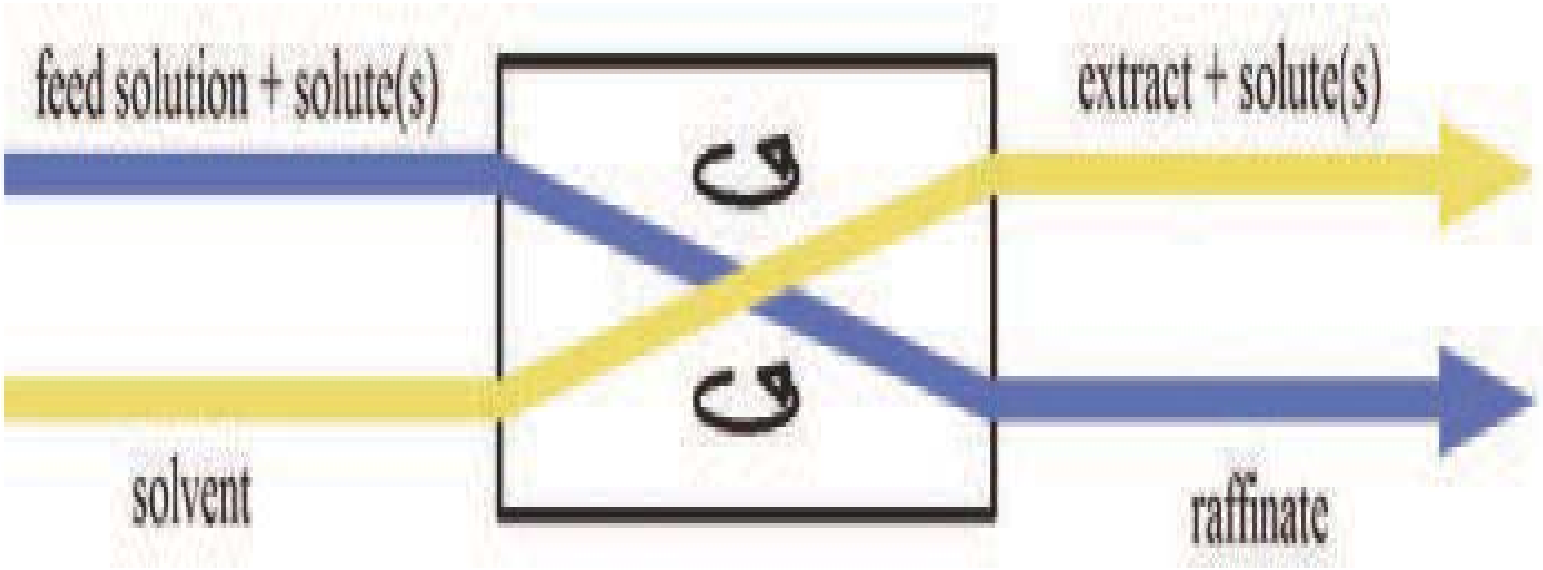
Part three

The process and application of solvent extraction

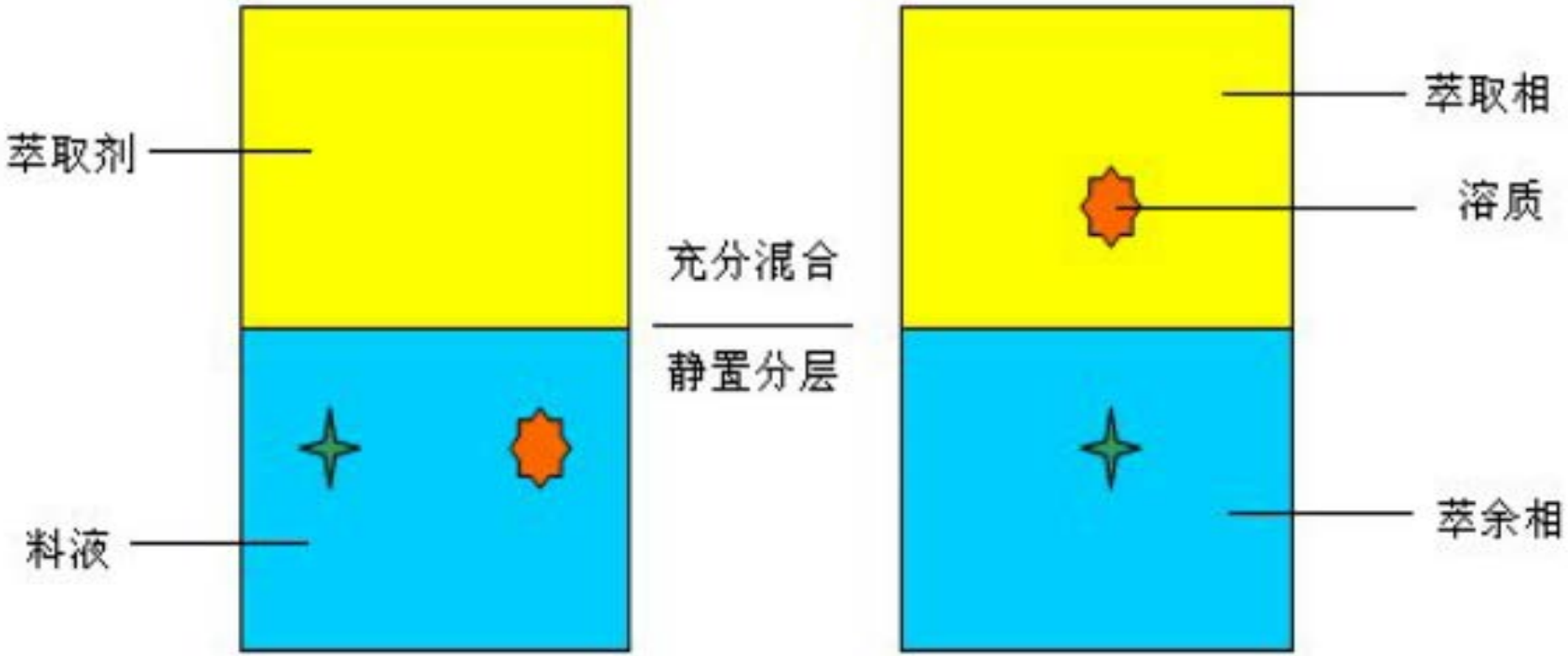


混合-沉降萃取槽



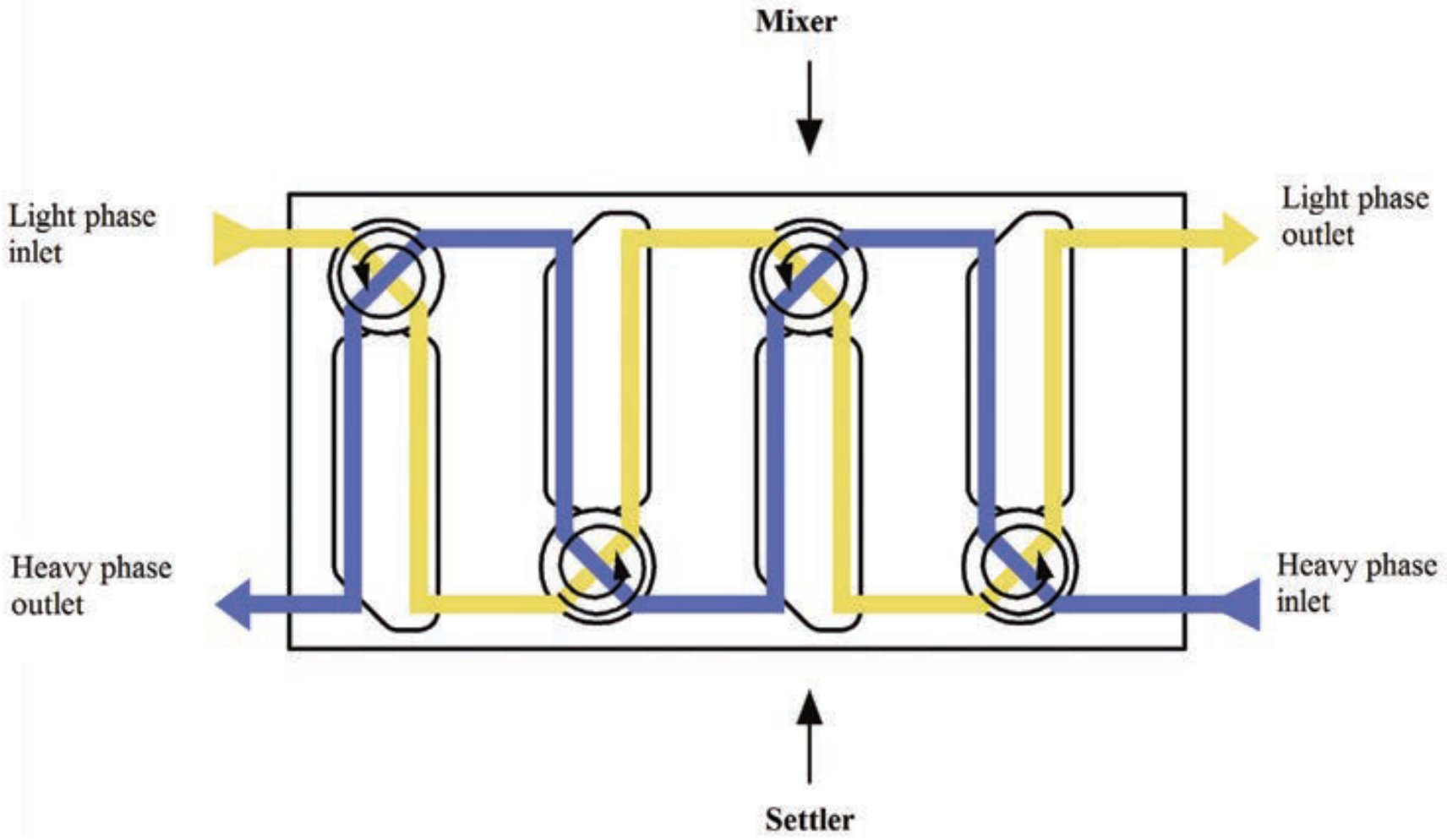
Liquid–liquid extraction (LLE) consists in transferring one (or more) solute(s) contained in a feed solution to another immiscible liquid (solvent). The solvent that is enriched in solute(s) is called extract. The feed solution that is depleted in solute(s) is called raffinate.

raffinate:萃余液，extract:萃取液，提取液



萃取操作示意图

a laboratory scale



4 stage battery of mixer-settlers for counter-current extraction

Solvent extraction involves two operations:

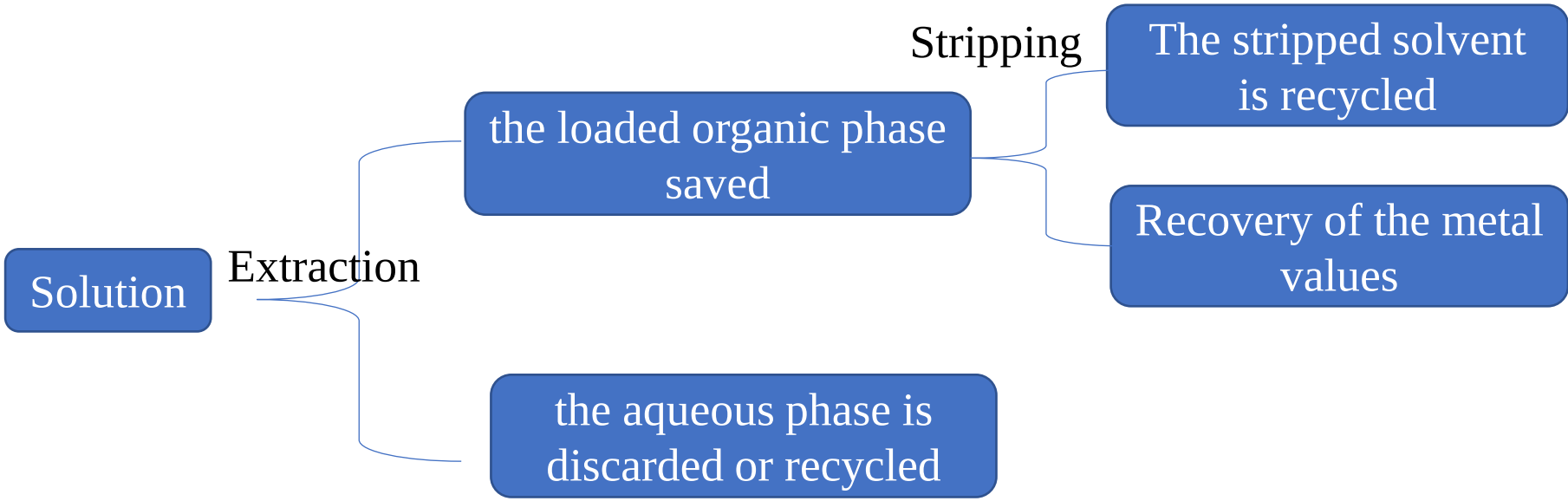
1) Extraction.

- The metal values in the aqueous phase are extracted by agitation with an organic solvent immiscible（不混溶的） in that phase. The two phases are then allowed to separate; the aqueous phase is discarded（丢弃的；废弃的） or recycled and the loaded（使负载） organic phase saved.

Loaded organic phase负载有机相
Immiscible不混溶的

2）Stripping（洗脱，反萃）.

- Recovery of the metal values from the loaded organic phase by agitation with a small volume of suitable solution. The stripped solvent is then recycled.
- In this way a concentrated solution containing the metal values in a relatively pure form is obtained.



- Solvent extraction as a means of separation and purification（提纯；净化） has for long been familiar to the chemical industry. Only in recent years, however, has it begun to achieve recognition（承认；认可） in the metallurgical field as a means of recovering metals in solution selectively.

然而，只有在最近几年，溶剂萃取才作为一种从溶液中选择性提取金属的方法，开始在冶金领域得到重视。

- The first large-scale（大规模的） use of solvent extraction in metallurgy was in connection with preparing uranium containing 1 ppm of contaminants（污染物） for the atomic energy program.

It has been proved in practice that solvent extraction is one of the most economical methods for metal recovery. Now it is being applied extensively（广阔的） in the following field:

- Recovery of a metal from a leaching solution;
- Separation of two or more closely related metals;
- Purification of leach solution i.e. removal（移除） of an unwanted impurity such as iron（铁）.

04

Part four

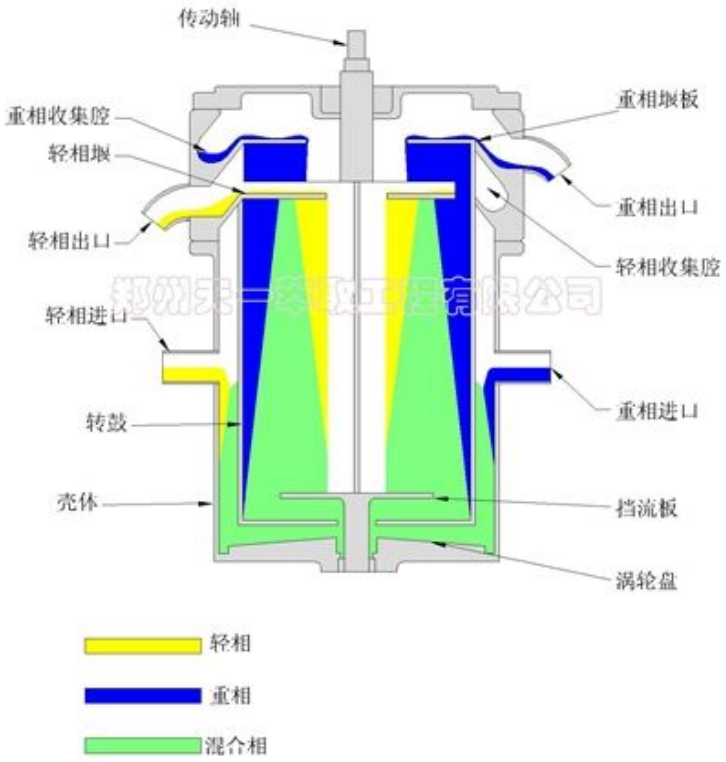
Properties and application of extractant

It is very important to choose an extractant(萃取剂) in solvent extraction（萃取）. An ideal extractant should fulfill the following requirements:

1) Selectivity
2) High extraction capacity（容量）
3) Easily striped（反萃）
4) Separates easily from water
5) Safe to handle
6) Stable during storage or when in contact with acids or alkalis, i.e.（也就是）does not during extraction or stripping.

- Concentration of the metal being collected can be effected using the solvent extraction (or liquid-liquid extraction) technique. This was developed for the extraction of uranium（铀） from very dilute（稀释了的） solution and until recently has been used only for some of the less common metals.

Effect：实现 concentration：富集



CWL-N型离心萃取机工作原理示意图

- It is now being used in copper extraction, however, and is likely to be applied to other base metals(贱金属) in the near future. It is also used in the separations of the platinum（铂） metals.
- Solvent extraction has the potential for separating metal from a relatively（相对地） impure solution at the same time as it（指溶液） concentrates it（指金属） but the effectiveness in this function depends on which metal and what impurities（杂质） are involved. Modern reagents can be very specific in their action.

溶剂萃取能够从不太纯的溶液中有效地分离出金属，同时使溶液中的金属得以富集，但其分离的效率取决于提取的金属种类和溶液中含有什么样的杂质。

The “solvent” is usually a complex organic compound with（具有） a replaceable hydrogen atom. Some of these are organic derivatives（衍生物） of phosphoric acid（磷酸） but the most now appear to be chelating compounds（螯合物） marketed under proprietary（专利的） trade names “LIX” and “KELEX” ----usually with a number appended（附录）.

(LIX extractant)一种能选择性萃取铜的羟肟类螯合萃取剂。`LIX`是Liquid Ion Exchanger(液体离子交换剂)的缩写。主要有脂肪族`alpha`-羟肟和芳香族`alpha`-羟肟两类。

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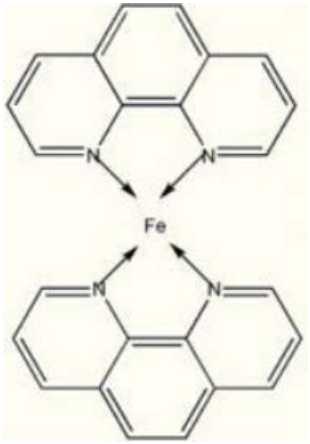
Part five

The practical application of solvent extraction



In use the reagent is dissolved in carrier（载体） which is usually based on kerosene（煤油）. This is agitated, with a similar volume of leach solution（浸出液） partially purified if necessary and with a sulfuric acid（硫酸） content of about 0.1%. Any copper in the leach solution is chelated（螯合） and enters the kerosene phase. The kerosene is allowed to rise and separate from the aqueous layer.

It is then agitated with a smaller volume of aqueous solution（水溶液） containing, this time, about 15% sulfuric acid. The reaction is reversed（反向的）. The copper escapes from the complex（复合体） and enters the aqueous solution. If the volume ratios（体积比） of the solutions have been selected for the greatest effect, the concentration of copper in the concentrated liquor（浓缩液） may be up to 50 times that in the leach solution, and this is a suitable feed（原料） for electrolysis tank（电解槽）.

$$\frac{1}{Z_1}A_1 + \frac{1}{Z_2}\overline{A_2} \rightleftharpoons \frac{1}{Z_1}\overline{A_1} + \frac{1}{Z_2}A_2$$

- Large-scale（大规模的） continuously operated mixer/settler units are in use as well as various types of columns in which the two immiscible（不互溶的） phases pass in opposite directions.
- In the perforated（有孔的） plate column some form of pulsation（脉冲） is needed to cause the lighter phase (the kerosene) to be injected through the perforations（孔） as suitably sized droplets（滴） to maintain a large interfacial （界面） area in the system. It will be appreciated that the reagent is continuously being regenerated（再生） for re-use.

在多孔板交换柱，振动液体相（煤油），使煤油呈液滴通过多孔板以增大接触面积。