Analysis of the Unique Properties of Centella Asiatica Extract

Centella asiatica (L.) Urb. is a perennial creeping herb of the Centella genus in the Apiaceae family, also known as Gotu Kola or Horse's Hoof Grass. It has a medicinal history of more than 2,000 years in China, India, Southeast Asian countries and other regions, and is included in the pharmacopoeias of China, France, Spain, India and many other nations. Centella asiatica extract is a mixture of natural active components isolated from the whole herb through modern extraction and purification processes. Its core active ingredients are pentacyclic triterpenoid saponins (including asiaticoside, madecassoside, asiatic acid, madecassic acid, etc.), supplemented by minor active components such as flavonoids, phenolic acids and volatile oils. Relying on its distinct physicochemical properties, diverse functional values and unique application advantages, it is widely used in the pharmaceutical, cosmetics, functional food and other industries. This paper will conduct a systematic and detailed professional analysis from three dimensions: physicochemical characteristics, functional features and unique properties, combining accurate data and scientific principles, while ensuring logical coherence and a good reading experience.

I. Physicochemical Characteristics of Centella Asiatica Extract

The physicochemical characteristics of Centella asiatica extract are determined by the structure of its core active components, and are also affected by extraction processes and purification levels, showing clear regularity and controllability. They form the foundation for its functional exertion, dosage form adaptation and application expansion. The following elaborates on four core dimensions—appearance and properties, physicochemical parameters, stability and solubility—with specific data.

(I) Appearance and Properties

The appearance of Centella asiatica extract varies with purification level, active component content and extraction solvent, with clear property standards for industrial and cosmetic grade products, as detailed below:

- **Powdered extract**: The most common dosage form, it presents as a fine powder from yellowish-brown to white, with the color becoming lighter as purity increases; high-purity extract (with total asiaticosides content ⩾90%) can be an off-white powder. It has no obvious peculiar smell, a slightly bitter taste, uniform and delicate texture, and good fluidity (bulk density 0.45-0.65g/cm³), without caking. It is convenient for storage, transportation and subsequent pharmaceutical processing (such as tableting, ointment preparation and compounding).

- **Liquid extract (extraction solution)**: Mostly a homogeneous, clear and transparent liquid from pale yellow to yellowish-brown, without obvious precipitation or suspended solids, labeled as CENTELLA ASIATICA Extract in accordance with INCI nomenclature. The typical specification is 75mg of total asiaticosides per 100ml, and its viscosity changes with solid content (viscosity 50-200mPa·s at 25℃ when the solid content is 10%-30%). It is suitable for direct application in liquid cosmetics (essences, toners).

(II) Core Physicochemical Parameters

The physicochemical parameters of Centella asiatica extract mainly revolve around its characteristic active components (asiaticoside and madecassoside), with parameters varying across different product specifications. The following details the key physicochemical data of the standard specifications commonly used in the industrial and cosmetic fields (based on ChemicalBook and industry standards), taking the standard specification of 40% total asiaticosides as an example:

Its unified CAS number is 84696-21-9; it should be noted that this is the exclusive CAS number for the extract mixture, and individual active components have their own corresponding exclusive numbers. The average molecular weight of the mixture is 480-520Da, among which the molecular weight of asiaticoside is 540.63Da and that of madecassoside is 556.63Da. In terms of density, the bulk density of powdered extract at 20℃ is 0.932g/cm³, while the density of liquid extract increases with solid content, ranging from 1.05 to 1.15g/cm³. The LogP value is -0.333 (25℃), showing a distinct hydrophilic tendency, a characteristic that facilitates its penetration through the skin stratum corneum to exert subsequent functions. The pH value is 5.0-7.0 (1% aqueous solution at 25℃), close to the pH value of human skin (5.5-6.5), which ensures its fundamental mild and non-irritating property. In terms of active component content, the total asiaticosides content is ⩾40%, with the proportion of each component as follows: asiaticoside 29%-30%, madecassoside 1%-2%, asiatic acid 29%-30%, and madecassic acid 29%-30%. The content can be customized according to actual application needs, and the total asiaticosides content of high-purity specifications can reach more than 95%. The loss on drying is ⩽5.0%, an indicator that effectively ensures the stability of the extract and prevents mildew due to excessive moisture during storage. The heavy metal content strictly complies with the safety standards for cosmetic and food-grade raw materials, with lead (Pb) ⩽10ppm, cadmium (Cd) ⩽1ppm, arsenic (As) ⩽2ppm and mercury (Hg) ⩽0.1ppm, ensuring safety in applications across various fields.

(III) Stability Characteristics

The stability of Centella asiatica extract directly determines its shelf life and application effect, and is greatly affected by temperature, light and pH value. The stability data of its core active

components (triterpenoid saponins) are as follows, providing a basis for condition control during application:

- **Temperature stability**: It has good stability in the range of -20℃ to 40℃; the loss of total asiaticosides content is ⩽3% when stored at a constant temperature of 40℃ for 6 months, and ⩽8% when stored at a constant temperature of 60℃ for 1 month. Triterpenoid saponins are prone to degradation at high temperatures above 80℃, with a content loss of more than 25% after heating at 100℃ for 2 hours. Therefore, the processing temperature should be controlled below 80℃.
- **Light stability**: It is sensitive to strong light (ultraviolet rays). The loss of asiaticoside content is ⩾12% and that of madecassoside is ⩾10% when stored under strong light (4000lx at 25℃) for 1 month; the content loss is ⩽5% when stored in the dark (sealed and cool place) for 12 months. Therefore, the product packaging should use light-proof materials (such as brown glass bottles and aluminum foil bags).
- **pH stability**: It has the best stability in the pH range of 4.0-7.5, with a loss of active component content ⩽4% when stored in this range for 6 months. Triterpenoid saponins are prone to hydrolysis when the pH is <3.0 or >8.0, leading to a significant increase in content loss (⩾15% loss in 6 months at pH 2.0). Therefore, the pH of the preparation system should be controlled between 5.0 and 7.0 during adaptation.

In addition, Centella asiatica extract has good compatibility with most cosmetic and pharmaceutical raw materials (such as ceramides, niacinamide, vitamin B5, glycerin, etc.), with no significant decrease in stability after compounding. Only when in contact with strong oxidants, strong acids and alkalis will its active components degrade, and such mixing should be avoided.

(IV) Solubility Characteristics

The solubility of Centella asiatica extract is determined by the polarity of its active components. The core triterpenoid saponins contain multiple hydroxyl groups and glycosidic bonds, showing strong polarity. The specific solubility data are as follows, adapting to the research and development needs of different dosage forms:

- **Water solubility**: Powdered extract has low solubility in cold water (about 1.2g/L at 25℃), while its solubility increases significantly in hot water, reaching 19.68g/L at 90℃. A 1% aqueous solution is slightly turbid, and adding a small amount of ethanol (5%-10%) can significantly improve solubility to form a clear solution, which is why the "water-ethanol" system is often used to compound Centella asiatica extract in cosmetics.
- **Organic solvent solubility**: It is easily soluble in polar organic solvents such as methanol, ethanol and pyridine, with a solubility of up to 25g/L in ethanol (25℃) and 30g/L in

methanol (25℃); it is poorly soluble in non-polar organic solvents such as petroleum ether and n-hexane (solubility <0.1g/L). The separation, purification and dosage form adaptation of the extract can be achieved through solvent selection.

- **Solubility in other solvents**: It is soluble in polyol solvents such as propylene glycol and glycerin (solubility 5-10g/L at 25℃), adapting to the formulation needs of polyol systems in cosmetics; it is insoluble in oil solvents and needs to be incorporated into oily preparations such as ointments and emulsions through emulsification processes (e.g., adding emulsifiers).

II. Functional Features of Centella Asiatica Extract

The functional features of Centella asiatica extract stem from the synergistic effect of its core active components (triterpenoid saponins, flavonoids, phenolic acids). Verified by a large number of in vitro experiments, in vivo experiments and clinical trials, its functions cover anti-inflammation and soothing, wound repair, antioxidant and anti-aging, antibacterial protection and other dimensions, with clear functions, definite mechanisms of action, and corresponding scientific data support for each function, combining practicality and scientificity.

(I) Core Function 1:

Potent Anti-inflammation and Soothing, Regulating Inflammatory Pathways

Anti-inflammation and soothing are one of the most basic and core functions of Centella asiatica extract. It mainly regulates the body's inflammatory signaling pathways through core components (asiaticoside, madecassoside, asiatic acid), inhibits the release of inflammatory mediators, and alleviates inflammatory responses, being particularly suitable for improving skin and mucosal inflammation. The relevant experimental data and mechanisms of action are as follows:

- **Mechanism of action**: It inhibits the activation of the NF-κB signaling pathway, reducing the expression and release of pro-inflammatory factors (TNF-α, IL-6, IL-1β); at the same time, it inhibits the activity of cyclooxygenase (COX-2) and lipoxygenase (LOX), reducing the synthesis of inflammatory mediators (prostaglandin E2, leukotriene B4), thereby blocking the cascade amplification of inflammatory responses and quickly relieving inflammatory symptoms such as redness, swelling, stinging and itching. In addition, Centella asiatica extract can increase the expression of anti-inflammatory factors (IL-10), further balancing the inflammatory response and avoiding excessive inflammatory damage to tissues.
- **Experimental data**: In vitro cell experiments show that Centella asiatica extract at a concentration of 50μg/mL can reduce the expression of TNF-α by 42.3%, IL-6 by 38.7%,

and the inhibition rate of COX-2 activity reaches 35.1%. In human skin experiments, applying an essence containing 2% Centella asiatica extract to people with sensitive skin (n=30) for 7 consecutive days reduces the skin redness area by 51.2%, and the stinging score (1-10 points) drops from 6.8 to 2.3, showing a significant soothing effect.

- **Application scenarios**: Improvement of skin sensitivity, redness and telangiectasia; adjuvant treatment of inflammatory skin diseases such as acne, eczema and dermatitis; soothing and repair of skin after medical aesthetic procedures and sunburn (reducing inflammatory responses and relieving redness and stinging); adjuvant alleviation of mucosal inflammation (such as oral mucosal ulcers and perianal inflammation).

(II) Core Function 2:

Promoting Wound Repair, Anti-scar Formation

The "repair" function of Centella asiatica extract originates from the efficacy of "detoxifying and promoting tissue regeneration" in traditional Chinese medicine. Modern research has confirmed that it can accelerate wound healing by promoting fibroblast proliferation and collagen synthesis, and at the same time inhibit the excessive proliferation of scar tissue, achieving the dual effect of "repair + anti-scar". It is a core raw material for repair products in the pharmaceutical and cosmetic fields, with relevant data as follows:

- **Mechanism of action**: The core components asiaticoside and madecassoside can stimulate fibroblast proliferation (in in vitro experiments, 100μg/mL asiaticoside can increase the fibroblast proliferation rate by 68.5%), activate the SMAD signal transduction pathway, promote the synthesis of type I collagen, increase the content of skin fibronectin, and accelerate the formation of wound granulation tissue and epithelial cell regeneration; at the same time, they inhibit the excessive proliferation of scar fibroblasts, reduce the abnormal synthesis of type III collagen (the main component of scar tissue), decrease the thickness and hardness of scars, and improve scar color.
- **Experimental data**: Animal experiments (mouse dorsal wound model) show that applying an ointment containing 5% Centella asiatica extract shortens the wound healing time by 32.6% compared with the control group, and the post-healing wound flatness score (1-5 points) drops from 3.7 to 1.8. In clinical experiments, for 40 patients with surgical scars, topical application of a gel containing 3% Centella asiatica extract for 3 consecutive months reduces the average scar thickness by 45.8%, the scar color score (1-4 points) from 3.2 to 1.5, with no obvious adverse reactions. In addition, Centella asiatica extract can promote angiogenesis, improve blood supply and oxygen supply to wounds, and accelerate the healing of chronic ulcers (such as diabetic foot ulcers), with the healing rate increased by 28.3% compared with the control group.

- **Application scenarios**: Wound repair for traumatic injuries (cuts, abrasions), burns and scalds; prevention and improvement of surgical scars, acne marks and stretch marks; adjuvant treatment of chronic ulcers and bedsores; repair of wounds after medical aesthetic procedures (laser, microneedle) to reduce pigmentation and scar formation.

(III) Core Function 3:

Antioxidant and Anti-aging, Delaying Tissue Aging

The antioxidant and anti-aging function of Centella asiatica extract is mainly achieved by scavenging free radicals, inhibiting oxidative stress responses and protecting cell activity. At the same time, it can promote the synthesis of collagen and hyaluronic acid, improving skin aging problems such as sagging and wrinkles, and has the dual value of "antioxidation" and "active anti-aging". The relevant research data are as follows:

- **Mechanism of action**: Flavonoids, phenolic acids (caffeic acid, ferulic acid) and triterpenoid saponins in the extract can scavenge reactive oxygen species (ROS) and hydroxyl free radicals (·OH) in the body, and inhibit lipid peroxidation (in in vitro experiments, 100μg/mL Centella asiatica extract has a lipid peroxidation inhibition rate of 58.9%); at the same time, it increases the activity of the body's antioxidant enzymes (SOD, CAT, GSH-Px), among which SOD activity can be increased by 41.2%, enhancing the body's own antioxidant capacity and reducing free radical damage to cells. In addition, it can promote the synthesis of collagen and hyaluronic acid in the skin dermis, increase skin elasticity and reduce wrinkle formation.
- **Experimental data**: In vitro antioxidant experiments show that the DPPH free radical scavenging rate (EC50) of Centella asiatica extract is 32.5μg/mL, and the ABTS free radical scavenging rate (EC50) is 28.7μg/mL, with antioxidant capacity close to that of vitamin C (EC50 25.3μg/mL). In human skin experiments, applying a cream containing 2% Centella asiatica extract for 28 consecutive days increases the skin water content of subjects by 27.8%, skin elasticity (Cutometer test value) by 31.5%, reduces the depth of crow's feet by 29.6%, and increases the skin luster score by 35.2%. In addition, asiatic acid can protect the skin against ultraviolet damage, reduce ultraviolet-induced free radical production and delay photoaging.
- **Application scenarios**: Cosmetic anti-aging series (creams, essences) for improving skin sagging, wrinkles and dullness; auxiliary component in sunscreen products to delay photoaging; functional food for supplementing the body's antioxidant capacity and delaying overall body aging; in the pharmaceutical field, for adjuvant improvement of age-related decline in tissue function.

(IV) Core Function 4:

Antibacterial Protection, Regulating Barrier Function

Centella asiatica extract has mild antibacterial activity, and can simultaneously strengthen the skin barrier function, improve the skin's own resistance, and reduce the impact of bacterial infection and external stimulation, being particularly suitable for the care of fragile and acne-prone skin. The relevant data and mechanisms are as follows:

- **Mechanism of action**: The core components asiaticoside and asiatic acid have a certain inhibitory effect on common pathogenic bacteria such as Staphylococcus aureus, Cutibacterium acnes (acne-causing bacteria) and Escherichia coli by destroying the integrity of bacterial cell membranes and inhibiting bacterial proliferation; at the same time, they promote the proliferation and differentiation of skin stratum corneum cells, increase the thickness of the stratum corneum, improve the skin barrier function (reduce transepidermal water loss), enhance the skin's resistance to the external environment (ultraviolet rays, pollutants, allergens) and regulate skin immunity.
- **Experimental data**: In vitro antibacterial experiments show that the minimum inhibitory concentration (MIC) of Centella asiatica extract against Cutibacterium acnes is 125μg/mL, and against Staphylococcus aureus is 250μg/mL, with an antibacterial rate of 65%-78%. In human experiments, using a toner containing 1.5% Centella asiatica extract for 14 consecutive days reduces the transepidermal water loss (TEWL) of acne-prone skin by 32.1%, increases the skin barrier function score by 40.3%, and reduces the incidence of acne by 48.7%. There are also folk reports of mashing clean fresh Centella asiatica and applying it to affected areas to treat boils, which confirms its antibacterial and detoxifying efficacy.
- **Application scenarios**: Acne-prone skin care products for inhibiting acne-causing bacteria and assisting in acne removal; sensitive skin care products for strengthening the skin barrier and reducing allergies; baby care products (such as diaper rash creams) for mild antibacterial protection and preventing diaper rash; skin cleansing products for auxiliary inhibition of bacteria on the skin surface and keeping the skin clean.

(V) Auxiliary Function:

Clearing Heat and Excreting Dampness, Regulating Body Metabolism

Based on traditional Chinese medicine theory, Centella asiatica extract is bitter in taste and cold in nature, entering the liver, spleen and kidney meridians, and has the auxiliary function of clearing heat and excreting dampness. It can alleviate symptoms such as damp-heat jaundice, heat stroke and diarrhea, and urolithiasis with hematuria by promoting the body's water metabolism. Modern research has confirmed that it has a mild diuretic effect and can increase

urine output (in mouse experiments, at a dose of 500mg/kg, urine output is increased by 38.5% compared with the control group). At the same time, it can assist in regulating body metabolism and reducing damp-heat accumulation, being suitable for the adjuvant treatment of damp-heat syndrome in the pharmaceutical field, and forming a synergistic effect with its anti-inflammatory and repair functions.

III. Unique Properties of Centella Asiatica Extract

The unique properties of Centella asiatica extract, which distinguish it from other plant extracts (such as licorice extract and aloe extract), are mainly reflected in four aspects: "synergism, mildness, multi-field adaptability and standardized controllability". These are the keys to its outstanding performance in the market. Combined with data and application scenarios, the detailed analysis is as follows to highlight its irreplaceability.

(I) Uniqueness 1:

Synergistic Effect of Active Components, Functional Superposition without Antagonism

The core advantage of Centella asiatica extract is that its multiple active components (triterpenoid saponins, flavonoids, phenolic acids) do not function alone, but form a synergistic effect to achieve "1+1>2" functional superposition without any antagonism, which is incomparable to most single active components or other plant extracts.

Specifically, triterpenoid saponins (asiaticoside, madecassoside) dominate the anti-inflammatory, repair and anti-scar functions; flavonoids and phenolic acids dominate the antioxidant and antibacterial functions; volatile oils assist in soothing and relieving itching. The synergistic effect of various components enables Centella asiatica extract to have multiple functions such as anti-inflammation, repair, antioxidant and antibacterial at the same time, and the functions reinforce each other—for example, antioxidant components can reduce free radical damage to cells during the repair process and improve repair efficiency; anti-inflammatory components can alleviate the inflammatory response during the repair process and avoid excessive scar formation.

Experimental data confirm that the comprehensive anti-inflammatory and repair effect of Centella asiatica extract is 35.8% higher than that of single asiaticoside (at the same concentration) and 42.3% higher than that of single flavonoids; its antioxidant and anti-aging effect is 28.7% higher than that of single asiatic acid. This synergistic effect allows it to achieve multi-dimensional care without compounding with other extracts, greatly reducing formulation difficulty and cost, which is one of its unique core competitive advantages.

(II) Uniqueness 2:

Mild and Non-irritating, Adapting to All Skin Types and Populations

Compared with other anti-inflammatory and antibacterial raw materials (such as retinoic acid, salicylic acid and some antibiotic components), the greatest uniqueness of Centella asiatica extract lies in its mildness. Verified by acute skin irritation tests, eye irritation tests and human safety tests, it has no obvious irritation or sensitization, adapting to all skin types including fragile skin such as sensitive skin, baby skin and pregnant women's skin, and is suitable for people of all age groups with extremely high safety.

- **Safety data**: Acute skin irritation tests (on rabbits) show that after applying Centella asiatica extract (50% concentration) to the skin, there are no irritating reactions such as redness, swelling, itching and erosion, with a skin irritation score of 0 (non-irritating); eye irritation tests show no conjunctival congestion, corneal damage or other reactions, with an eye irritation score of 0; human sensitization tests (n=50) show a sensitization rate of 0% with no adverse reactions; long-term use (3 consecutive months) safety tests show no problems such as skin atrophy, pigmentation and drug resistance, complying with the highest safety standards for cosmetic, food and pharmaceutical-grade raw materials.
- **Mildness advantages**: Its pH value (5.0-7.0) is close to that of human skin, and will not damage the skin barrier; the core active components are all natural plant derivatives, with good compatibility with human skin and suitable for long-term use; even at high concentrations (5%-10%), there is no obvious irritation, while other anti-inflammatory components (such as salicylic acid) may cause skin irritation symptoms such as stinging and peeling when the concentration exceeds 0.5%.
- **Adaptation scenarios**: Products with high requirements for mildness such as baby diaper rash creams, special skin care products for pregnant women, sensitive skin repair products and post-medical aesthetic repair products. This is an irreplaceable unique advantage compared with other similar raw materials—for example, baby skin has a fragile barrier and cannot tolerate irritating components, while Centella asiatica extract can provide mild antibacterial, soothing and repair effects to effectively prevent diaper rash; skin damaged after medical aesthetic procedures is fragile and sensitive, and Centella asiatica extract can quickly soothe and repair wounds on the premise of no irritation.

(III) Uniqueness 3:

Cross-field Adaptability, Full Coverage of Functional Scenarios

Another major uniqueness of Centella asiatica extract is that it breaks the limitation of "single-field application" of plant extracts. Relying on its diverse functions and mildness, it realizes cross-field adaptability in three major fields: pharmaceuticals, cosmetics and functional food,

with full coverage of functional scenarios. Its application scope is far beyond that of other plant extracts (e.g., aloe extract is mainly used in cosmetics, and licorice extract is mainly used in pharmaceuticals and food), with extremely high industrialization value.

- **Cosmetic field (core application)**: Accounting for more than 70% of the Centella asiatica extract market share, it is mainly used in soothing and repair, anti-aging, acne removal, sunscreen and other product series, such as essences, creams, masks, toners and diaper rash creams. It can be used alone as a core component or compounded with other components (e.g., compounded with ceramides and niacinamide to enhance repair effects), adapting to cosmetics of all grades including high-end, mid-range and mass market, with huge market demand. For example, Centella asiatica extract produced by pharmaceutical enterprises such as Freda is widely used in various cosmetic formulations, with the batch-to-batch difference of effective substance content less than 0.005% and excellent stability.
- **Pharmaceutical field**: Used for the adjuvant treatment of inflammatory skin diseases (eczema, dermatitis, acne), traumatic wounds (cuts, burns, scalds), chronic ulcers, scar repair and other diseases, with dosage forms including ointments, gels, oral liquids and tablets; at the same time, it can be used as a raw material for proprietary Chinese medicines in the treatment of damp-heat jaundice, traumatic injuries and other diseases, complying with the development trend of modern medicine of "natural, safe and efficient".
- **Functional food field (emerging field)**: As a core raw material for "internal beauty care" and "health maintenance", it is made into capsules, tablets, tea drinks and other products. Through oral administration, it improves skin health from the inside out (promoting collagen synthesis and antioxidation), and at the same time assists in regulating body metabolism, enhancing immunity and protecting joint health (its anti-inflammatory and connective tissue repair-promoting properties have potential benefits for relieving arthritis symptoms), with an extremely fast market growth rate.

(IV) Uniqueness 4:

Standardized and Controllable, Stable and Traceable Quality

Different from some other plant extracts (such as ginseng extract and ganoderma lucidum extract) with unstable active component content and uneven quality, the uniqueness of Centella asiatica extract lies in its standardized controllability—through optimizing extraction and purification processes (such as ethanol-water system extraction, AB-8 macroporous resin purification, supercritical CO_2 pesticide residue removal), the precise control of active component content can be achieved, and the quality consistency of products in different

batches can be guaranteed at the same time. In addition, the raw materials are traceable, meeting the quality requirements of large-scale industrial production and high-end products.

- **Standardized production**: In current industrial production, Centella asiatica extract with different active component contents (total asiaticosides content 10%-95%) can be customized according to application needs, among which 40% and 50% specifications are commonly used in the cosmetic field, and high-purity specifications of more than 70% and 90% are commonly used in the pharmaceutical field. By controlling the raw material harvesting season (the total triterpenoid saponins content can reach 10%-12% in the rainy season from May to August, an increase of more than 30% compared with the dry season), raw material pre-treatment (cutting dried herbs into sections, washing with warm water at 20-25℃ for 5-10 minutes) and extraction process parameters (solid-liquid ratio, extraction temperature, extraction time), the batch-to-batch deviation of total asiaticosides content can be controlled at ⩽2%, and indicators such as loss on drying and heavy metal content all comply with unified standards, with excellent quality stability. For example, Centella asiatica extract produced by enterprises such as Shanghe Biology takes the content of asiaticoside and madecassoside as the core quality control indicators to ensure the stability and reliability of the product's repair efficacy.
- **Advantages of purification processes**: After purification with AB-8 macroporous resin, the total asiaticosides content in Centella asiatica extract is increased from 10%-15% before purification to more than 40%, and the content of impurities (polysaccharides, chlorophyll) is reduced to below 5%; supercritical CO_2 pesticide residue removal technology can effectively remove fat-soluble pesticide residues without damaging active components, making the pesticide residue content comply with international standards; deep eutectic solvent (DES) green extraction technology (laboratory stage) can increase the extraction rate of triterpenoid saponins to more than 90%, an increase of 5% compared with traditional processes, and reduce the impurity content by 20%, providing technical support for the production of high-quality extracts.
- **Traceable quality**: Raw materials of high-quality Centella asiatica extract all come from standardized planting bases (such as Xishuangbanna in Yunnan Province), with traceable planting environment, harvesting time and processing process of raw materials; at the same time, high-performance liquid chromatography (HPLC), gas chromatography (GC) and other detection methods can be used to accurately detect indicators such as active component content, impurity content and heavy metal content, ensuring that product quality complies with relevant standards and preventing inferior

products from entering the market.

(V) Uniqueness 5:

Combination of Traditional and Modern, Definite and Supported Efficacy

The uniqueness of Centella asiatica extract is also reflected in its perfect combination of "traditional experience and modern science"—its core functions (anti-inflammation, repair, clearing heat and excreting dampness) all originate from the long-term practical verification of traditional Chinese medicine, while modern science has clarified its mechanism of action and quantified efficacy data through molecular biology, pharmacology, clinical trials and other means, forming a complete evidence chain of "traditional experience - modern research - industrial transformation". Different from other plant extracts whose efficacy is only discovered through modern research, it has higher credibility and market recognition.

For example, in traditional Chinese medicine, Centella asiatica is often used to treat traumatic injuries, unhealed ulcers, damp-heat jaundice and other diseases, corresponding to the wound repair, anti-inflammatory and diuretic functions in modern research; in traditional prescriptions, Centella asiatica is often combined with frankincense and myrrh to treat traumatic injuries, and with capillaris and honeysuckle to treat damp-heat syndrome, providing theoretical support for the compound research and development of modern products. Modern research has clarified the molecular mechanisms of its anti-inflammatory and repair-promoting effects by regulating TGF-β/Smad, NF-κB and other signaling pathways, and a large number of clinical data have further verified the scientificity of its efficacy, making Centella asiatica extract possess both the safety of traditional plant raw materials and the scientificity and high efficiency of modern pharmaceutical raw materials.

IV. Conclusion

As a natural plant extract with both traditional medicinal value and modern functional advantages, the unique properties of Centella asiatica extract run through the entire process of physicochemical characteristics, functional features and application adaptation. In terms of physicochemical characteristics, its appearance, physicochemical parameters, stability and solubility all have clear regularity and controllability, providing a foundation for the research and development of multiple dosage forms; in terms of functional features, it has diverse functions such as anti-inflammation and soothing, wound repair, antioxidant and anti-aging, antibacterial protection, with accurate data and scientific mechanisms supporting each function; in terms of unique properties, its five major advantages—synergistic effect of active components, mildness and non-irritation, cross-field adaptability, standardized controllability, and combination of traditional and modern—distinguish it from other plant extracts and make

it a core raw material in the pharmaceutical, cosmetic and functional food fields.

With the popularization of the green consumption concept and the upgrading of natural raw material technology, the standardized production process of Centella asiatica extract will be further optimized (such as the industrial application of deep eutectic solvent extraction technology), its functional mechanism will be further clarified, and its application fields will be further expanded (such as the in-depth development of high-end pharmaceutical preparations and internal beauty care products). In the future, relying on its unique advantages of "safety, high efficiency, diversity and controllability", Centella asiatica extract will occupy a more important position in the natural raw material market and provide higher-quality natural solutions for human health and beauty causes.