Analysis of Unique Properties of Calcium Carbonate

Calcium Carbonate (CAS No.471-34-1, E170) is the world's most widely used inorganic calcium nutritional fortifier and quality improver. It is certified by authoritative standards including China **GB 1886.214-2016**, FDA GRAS, JECFA, EFSA and European Union E170. Featuring ultra-high calcium content, cost-effectiveness, physical and chemical stability, strong alkaline neutralization and high-whiteness filling performance, it is widely applied in food, pharmaceutical, daily chemical and industrial fields. It is the basic calcium source and functional filler with the highest cost performance and the broadest application scenarios.

I. Physicochemical Characteristics

1. Basic Physicochemical Parameters

1.1 Official Chemical Name: Calcium Carbonate (Limestone / Calcite)

1.2 Structural Formula: Ca^{2+} CO_3^{2-}

1.3 Molecular Formula: $CaCO_3$

1.4 Exact Molecular Weight: 100.09

1.5 Theoretical Calcium Content: 40.04% (the highest among all common calcium sources)

1.6 Industrial/Food Grade Purity: ≥99.0% (on dry basis, complying with GB 1886.214-2016)

1.7 Appearance Properties: White to off-white fine crystalline powder, odorless and tasteless

1.8 Solubility Index:

• Solubility in pure water at 25℃: 0.0013 g/100 mL (extremely insoluble)

• Soluble in dilute acids (hydrochloric acid, acetic acid, citric acid) with CO_2 bubbles generated during dissolution

• Insoluble in organic solvents such as ethanol and acetone

• Aqueous solution pH (10% suspension, 25℃): 9.0~10.0, weakly alkaline

1.9 Density: 2.70~2.95 g/cm³

1.10 Particle Size: Food grade normally 95% passing 200~400 mesh; ultra-fine/nano grade reaches micron level

1.11 Hygroscopicity: Basically non-hygroscopic with excellent stability in dry environment

2. Stability Characteristics

2.1. Thermal Stability: Stable at **≤800°C**; decomposes into \(\ce{CaO}\) and \(\ce{CO2}\) at 825~900°C. Tolerates conventional food baking, extrusion and high-temperature sterilization processes.

2.2. Chemical Stability: No oxidation, discoloration or deliquescence under normal temperature and pressure. It features inert chemical properties and does not react with vitamins, oils or pigments.

2.3. Acid-Base Stability:

• Alkaline environment (pH > 7): Stable and insoluble

• Acidic environment (pH < 6): Rapidly reacts and dissolves

2.4. Storage Stability: Shelf life over 36 months under sealed and dry conditions with no quality degradation.

3. Authoritative Safety Parameters

3.1. National Standard Basis of China:

• Food Additive: GB 1886.214-2016

• Nutritional Fortifier: GB 14880-2012

3.2. International Authoritative Certifications: FDA GRAS, JECFA (Unrestricted ADI), EFSA, EU E170, CAC Standards.

3.3. Toxicological Safety: Acute oral \(\ce{LD50 > 6450 mg/kg}\) (rat), non-toxic, non-teratogenic and non-carcinogenic.

II. Functional Characteristics (Performance Comparison with Mainstream Calcium Sources)

1. Comparison of Calcium Content and Cost Efficiency

• Calcium Carbonate: Calcium content 40.04%, the lowest cost, king of cost performance.

• Calcium Citrate: Calcium content 21.08%, high cost.

• Calcium Lactate: Calcium content 13.00%, high cost.

• Calcium Gluconate: Calcium content 8.90%, extremely high cost.

2. Comparison of Absorption Mechanism and Gastrointestinal Tolerance

• Calcium Carbonate: Relies on gastric acid to dissolve into calcium ions for absorption; high absorption rate after meals. May cause constipation, abdominal distension and flatulence.

• Calcium Citrate: Gastric acid-independent, stable absorption on empty stomach/after meals; mild and non-irritating.

• Calcium Lactate: Mild property but low calcium content and average absorption effect.

3. Comparison of Process Adaptability and Sensory Characteristics

• Calcium Carbonate: High whiteness, high hiding power, non-hygroscopic and good fluidity. Extremely insoluble in water and prone to precipitation; high temperature resistant and non-discoloring.

• Calcium Citrate: Slightly soluble, dissolves in acidic environment; stable with no precipitation.

• Calcium Lactate / Calcium Gluconate: Good water solubility but strong hygroscopicity, easy caking and short shelf life.

III. Summary of Core Unique Properties

1. Ultra-high Calcium Content and Optimal Cost

The theoretical calcium content is 40.04%, 1.8~4.5 times that of organic calcium. It realizes low addition amount and high calcium supplementation, greatly reduces raw material cost and formula space, and is the first choice for large-scale industrial production.

2. Extremely Stable Physicochemical Properties and Long Shelf Life

Non-hygroscopic, non-oxidizing, non-discoloring and non-caking. Tolerates extreme processing conditions, significantly extends product shelf life and reduces storage and transportation losses.

3. High Whiteness and High Filling Performance for Quality Improvement

Whiteness **≥95%, providing excellent whitening, thickening, filling and anti-caking** functions. Widely used in flour, milk powder, solid beverages and biscuits to improve texture, taste and appearance.

4. Weak Alkaline Neutralization for Stomach Protection and Acid Inhibition

Its weak alkalinity can neutralize gastric acid and relieve heartburn. It is the main ingredient of antacids, suitable for people with excessive gastric acid, with dual effects of

calcium supplementation and stomach protection.

5. Global Compliance and Universal Application

Complies with mainstream global standards in China, the United States, the European Union, Japan and other regions. No barriers for domestic sales and export, covering food, pharmaceutical, health care product and industrial fields.

IV. Commercial Value

1. Extreme Cost Control to Improve Gross Profit

The high calcium content reduces the addition amount by 50%~75%, significantly cutting raw material costs. Meanwhile, it acts as a filler to lower the dosage of other auxiliary materials, presenting obvious comprehensive cost advantages.

2. Quality Upgrading to Enhance Product Competitiveness

Utilizing its high whiteness and stability, it improves product color, texture and shelf life, building a high-end, stable and high-quality market image.

3. Multi-function Integration to Expand Formula Boundaries

Integrates nutritional fortification, quality improvement, pH adjustment and anti-caking filling functions into one material. It simplifies formulas, reduces the types of additives, and is applicable to complex processes such as solid, semi-solid and baking products.

4. Zero Safety Risk for Unimpeded Market Access

With a century-long application history, global authoritative certifications and sufficient toxicological data, it has no safety disputes. Suitable for all groups including infants, middle-aged and elderly people, and pregnant women with zero compliance risks.

V. Target Application Markets

- **Nutritionally Fortified Foods:** Formula milk powder, breakfast cereals, nutritional oatmeal, biscuits, noodles (efficient calcium supplementation with optimal cost).
- **Solid Beverages / Milk Powders:** Protein powder, soybean milk powder, meal replacement powder (anti-caking, thickening, improving fluidity).
- **Pharmaceutical & Health Care Products:** Calcium tablets, antacids, gastric medicines, mineral tablets (high calcium content, acid inhibition, cost-effective).
- **Flour Products:** Flour, noodles, steamed buns (whitening, gluten strengthening, texture improvement).
- **Pet Food:** Dog food, cat food, nutritional ointment (efficient calcium supplementation, bone strengthening, economical cost).
- **Industrial Applications:** Plastics, rubber, coatings, papermaking (high filling capacity, cost reduction, performance improvement).

Conclusion

With six core properties of ultra-high calcium content, extreme cost performance, superior physicochemical stability, high whiteness filling, weak alkaline neutralization and global compliance, Calcium Carbonate has become the absolute benchmark of inorganic calcium sources. It perfectly balances high calcium demand and cost control, possessing dual values of nutritional fortification and quality improvement. It is an indispensable and irreplaceable basic core raw material in the food industry, pharmaceutical health care, pet nutrition and industrial fields.