

Aspartic acid

Table of Contents

summary

Chemical Structure

Synthesis

- Chemical Synthesis

- Biological Synthesis

 - Enzymatic Pathways

 - Regulation of Biosynthesis

Properties

- Physical Properties

- Chemical Properties

Biological Role

- Neurotransmitter Function

- Metabolic Involvement

- Amino Acid Biosynthesis

Applications

- Pharmacological Repurposing

- Combination Therapies

- Nutritional Considerations

- Research and Safety

Health Implications

- Side Effects

- Research on Efficacy

- Nutritional Considerations

Research

- Future Directions

- Overview of D-Aspartic Acid

- Pharmacological Effects

 - D-Aspartic Acid Supplementation

 - Neurological Implications

- Safety and Side Effects

Check <https://storm.genie.stanford.edu/article/1147096> for more details

Stanford University Open Virtual Assistant Lab

The generated report can make mistakes.

Please consider checking important information.

The generated content does not represent the developer's viewpoint.

summary

Aspartic acid, also known as ~~α~~amino butanedioic acid, is a non-essential amino acid with the chemical formula $C_4H_7NO_4$, distinguished by its two carboxyl groups, which grant it acidic properties at physiological pH levels.^{[1][2]} It is one of the 20 standard amino acids utilized in protein synthesis and plays critical roles in various biological functions, including neurotransmission and metabolic processes. As such, aspartic acid is pivotal in maintaining cellular homeostasis and energy production, as it contributes to the citric acid cycle and serves as a precursor for the biosynthesis of other essential amino acids such as methionine and threonine.^{[3][4][5][6][7]}

The compound exists in two stereoisomeric forms: the L-isomer, which is prevalent in protein synthesis, and D-aspartic acid, which is less involved in protein formation but has garnered attention for its potential therapeutic applications, particularly in neurological health and hormone regulation.^{[8][9]} The role of D-aspartic acid as an excitatory neurotransmitter, especially in binding to N-methyl-D-aspartate (NMDA) receptors, underlines its importance in learning and memory, while also highlighting its potential implications in treating conditions like Alzheimer's disease and schizophrenia.^{[5][10][9]}

Aspartic acid's synthesis occurs both through biological pathways, involving the transamination of oxaloacetate, and through industrial methods such as the amination of fumarate.^{[11][4]} Despite its essential functions, concerns have been raised regarding the potential side effects of high doses of D-aspartic acid supplements, including gastrointestinal disturbances and effects on the nervous system, emphasizing the need for cautious regulation of its intake.^{[12][9]} Ongoing research continues to explore the efficacy and safety of D-aspartic acid, particularly in pharmacological contexts, making it a notable topic within the fields of biochemistry and nutrition.^{[13-][14]}

Chemical Structure

Aspartic acid, known chemically as ~~α~~amino butanedioic acid, has the molecular formula $C_4H_7NO_4$. Its structure features two carboxylic acid groups, which categorize it as a dicarboxylic amino acid, and contributes to its acidic nature at physiological pH levels^{[1][2]}. The linear formula of aspartic acid can be represented as $HOOC-CH_2-CH(NH_2)-COOH$, illustrating its carboxyl and amino functional groups^{[15][16]}.

The L-isomer of aspartic acid, which is one of the 22 proteinogenic amino acids, plays a vital role in protein synthesis and biological functions[3][8]. In contrast, D-aspartic acid, another stereoisomer, is less involved in protein synthesis but is found in certain peptides and acts as a neurotransmitter[8][17]. The structural integrity of aspartic acid is essential for its biological roles, enabling it to participate in various chemical reactions, such as transamination with other amino acids[2].

The average molar mass of aspartic acid is approximately 133.10 g/mol[18][8]. In addition to its presence in protein structure, aspartic acid's unique chemical properties allow it to participate in biochemical pathways and reactions, further highlighting its significance in both nutrition and cellular metabolism[2][17].

Synthesis

Aspartic acid can be synthesized through various metabolic pathways, primarily involving transamination reactions and other enzymatic processes.

Chemical Synthesis

Industrially, aspartate is produced via the amination of fumarate, a reaction catalyzed by L-aspartate ammonia-lyase[11]. This method enables the efficient production of aspartic acid on a commercial scale.

Biological Synthesis

In biological systems, aspartic acid is synthesized by the transamination of the precursor molecule oxaloacetate. This pathway is sufficient to meet the amino acid requirements of the body, designating aspartic acid as a non-essential amino acid[4]. Additionally, aspartate serves as a critical starting point for the biosynthesis of other amino acids, including lysine, threonine, isoleucine, and methionine, particularly in plants and microorganisms[19][20].

Enzymatic Pathways

The synthesis of aspartate is facilitated by several key enzymes. The initial step often involves the conversion of oxaloacetate to aspartate through a transamination reaction, where an amino group is transferred to the keto acid[21]. This transamination process is crucial, as it links the metabolism of carbohydrates and amino acids, allowing for the efficient utilization of metabolic intermediates.

Furthermore, the biosynthesis of aspartate and its derivatives involves the action of various enzymes, such as aspartokinase and aspartate-semialdehyde dehydrogenase. These enzymes play significant roles in the branching pathways leading to the synthesis of essential amino acids[21][22].

Regulation of Biosynthesis

The biosynthetic pathway of aspartate is tightly regulated to ensure a balanced supply of amino acids. Feedback inhibition mechanisms are in place, where the end products of the pathway, such as isoleucine and methionine, can inhibit earlier steps, thereby modulating the flow of metabolites through the pathway[23]. Such regulatory controls are vital for maintaining cellular homeostasis and responding to varying metabolic demands.

Properties

Aspartic acid, also known as aspartate, is a non-essential amino acid with significant biological functions. It possesses the chemical formula $\text{HOOCCH}(\text{NH}_2)\text{CH}_2\text{COOH}$ and is one of the 20 standard amino acids used in protein synthesis[2].

Physical Properties

Aspartic acid appears as a white, crystalline solid and is soluble in water.

Molecular weight: 133.

Melting point: 271-272 °C

Boiling point: 339 °C

Solubility in water: 5.

pKa values: 1.88, 3.65, 9.60[2].

Chemical Properties

Aspartic acid can undergo various chemical reactions typical of amino acids, and it can act as both an acid and a base due to its carboxyl groups. It is important to note that while aspartic acid is not classified as an essential amino acid, deficiencies may occur under specific physiological conditions. Additionally, high doses of aspartic acid can exhibit toxic effects, emphasizing the need for careful regulation of its intake[2].

Biological Role

Aspartic acid, an amino acid, serves multiple critical functions within biological systems, primarily as a neurotransmitter, metabolic intermediary, and component of protein synthesis. It is recognized as an important metabolite in various organisms, including its roles as an *Escherichia coli* metabolite and a mouse metabolite[24][25].

Neurotransmitter Function

In the central nervous system, aspartic acid acts as an excitatory neurotransmitter, specifically by binding to and activating N-methyl-D-aspartate (NMDA) receptors[5]. This activity is essential for various neurological functions, including learning and memory, thereby influencing nervous system development and hormone regula-

tion[10][25]. Aspartate's role as a neurotransmitter extends to facilitating cell-to-cell signaling, making it integral in the communication between neurons[10].

Metabolic Involvement

Aspartic acid is pivotal in several metabolic pathways. It contributes to the urea cycle, where it combines with citrulline to form argininosuccinate, a key step in the detoxification of ammonia and the maintenance of nitrogen balance[5]. Furthermore, aspartic acid is involved in the citric acid cycle (Krebs cycle), where it is converted into oxaloacetate, enhancing energy production through the oxidation of nutrients and contributing to ATP synthesis, the primary energy currency of cells[5][26].

Amino Acid Biosynthesis

In addition to its metabolic roles, aspartic acid is vital for the biosynthesis of other amino acids. It serves as a precursor for several essential amino acids, including methionine, threonine, and isoleucine, through well-characterized biosynthetic pathways[6][7]. The synthesis of aspartate itself occurs via a transamination reaction between oxaloacetate and glutamate, catalyzed by aspartate aminotransferase[7]. This interconnection between aspartate and various metabolic pathways underscores its central role in cellular metabolism and amino acid homeostasis.

Applications

Pharmacological Repurposing

Aspartic acid, particularly in its D-form (D-aspartic acid), has gained attention for its potential therapeutic applications. Repurposing pharmacological agents offers advantages in drug development due to expedited FDA review processes, as existing safety and efficacy data can be leveraged for new indications[13]. D-aspartic acid has been studied for various conditions, including schizophrenia, Alzheimer's disease (AD), and hormone-related issues such as fertility[9][27].

In the context of Alzheimer's disease, D-aspartic acid is being investigated for its role in enhancing neurotransmitter function and possibly alleviating symptoms. For instance, drugs like Riluzole and Minocycline, which are in trials for mild AD, exemplify how existing medications can be repurposed to target neuroinflammation and improve cognitive function[13].

Combination Therapies

Combination therapies involving D-aspartic acid aim to synergistically enhance treatment efficacy by pairing pharmacological approaches with non-pharmacological interventions. These combinations can target multiple pathways involved in AD, offering a flexible approach tailored to individual patient needs[13]. For instance, combining D-aspartic acid with neurostimulation techniques may provide dual benefits in both symptom management and disease modification[13].

Nutritional Considerations

Dietary sources of L-aspartic acid, such as meat, fish, and dairy products, are essential for maintaining optimal levels in the body, particularly for older adults who may be at risk for cognitive decline[28][29]. Epidemiological studies suggest that higher protein intake, which includes amino acids like aspartic acid, is associated with a reduced risk of mild cognitive impairment and dementia[29].

Furthermore, D-aspartic acid supplementation is often considered for those not meeting their nutritional needs through diet alone. Recommended doses generally range from 3 to 6 grams per day for specific health benefits, although it is crucial for individuals to consult healthcare providers before starting any supplementation regimen[14][27].

Research and Safety

Despite the potential benefits, research on D-aspartic acid remains mixed, necessitating further clinical trials to confirm its efficacy and safety profile[14]. While initial studies suggest that D-aspartic acid is safe for short-term use, ongoing evaluation is necessary to assess long-term effects and possible side effects[14][27]. Given the complexity of mental health and neurodegenerative conditions, professional guidance is advised for anyone considering its use for therapeutic purposes[9].

Health Implications

Aspartic acid, particularly in the form of D-aspartic acid supplements, can have various health implications, both beneficial and adverse.

Side Effects

Some individuals may experience gastrointestinal symptoms such as bloating, gas, and diarrhea, particularly when supplements are consumed in excessive amounts[12]. Additionally, high doses of D-aspartic acid may over-stimulate the nervous system, leading to symptoms like restlessness, irritability, and insomnia. This is particularly concerning for individuals sensitive to changes in neurotransmitter levels[12].

Kidney function can also be compromised due to high levels of aspartic acid. The kidneys are responsible for filtering excess amino acids, and an overload can lead to strain or potential long-term damage, especially in those with pre-existing kidney conditions[12]. Allergic reactions, although rare, are another potential risk, with symptoms including itching, rash, swelling, and dizziness[9].

Clinical trials have also indicated that D-aspartic acid can cause irritability, anxiety, fast heart rate, and headaches[9]. Furthermore, due to its influence on hormone levels, it may interact with medications affecting testosterone and estrogen, such as birth control pills, seizure medications, and certain antidepressants[9]. For individuals with chronic conditions, pregnant or lactating women, and those over 65 or children,

the safety of D-aspartic acid supplementation is not well established, necessitating consultation with healthcare professionals before use[9].

Research on Efficacy

A systematic review has assessed the impact of D-aspartic acid supplementation on body composition among healthy, physically active individuals. The review utilized the PICO framework to structure its investigation, focusing on the intervention of D-aspartic acid against a placebo, with the outcome being changes in body composition[30]. However, further clinical trials are necessary to confirm the effects and safety of these supplements, particularly at higher doses and with long-term use[9].

Nutritional Considerations

Dietary sources of aspartic acid include various foods such as meats (beef, chicken, turkey), fish (salmon, tuna), dairy products, and eggs[28]. A balanced diet typically provides adequate aspartic acid and other essential amino acids, reducing the need for supplementation in most individuals[31][11].

Research

Future Directions

Future research on D-aspartic acid is needed to explore its multifaceted roles in health and disease. There is particular interest in how it may interact with pharmacological therapies in treating neurological disorders, and ongoing clinical trials are exploring various combinations of treatments that could potentially enhance therapeutic efficacy and patient outcomes in conditions such as Alzheimer's disease[13]. The integration of precision medicine approaches that consider individual variations in response to D-Asp and other agents may also be an important avenue for future investigation.

Overview of D-Aspartic Acid

D-aspartic acid (D-Asp) is a non-essential amino acid that is naturally synthesized in the body and can also be obtained from dietary sources, particularly protein-containing foods[17]. It plays a crucial role in various physiological functions, especially within the nervous and reproductive systems, rather than in protein synthesis[32]. Research into D-Asp has highlighted its potential implications in health, particularly concerning its supplementation and effects on body composition and neurological functions.

Pharmacological Effects

D-Aspartic Acid Supplementation

Recent studies have focused on the impact of D-aspartic acid supplementation on body composition in physically active individuals. A systematic review was conducted to assess the changes in body composition resulting from D-Asp intake compared to placebo[30]. The findings suggested that D-Asp may have beneficial effects in this demographic, although further research is required to solidify these conclusions and account for variables such as sample size and evaluation outcomes[29].

Neurological Implications

D-aspartic acid has been studied for its role in mitigating pain and neurological dysfunction associated with certain conditions. Research indicates that D-Asp treatment may reduce pain and normalize β amyloid levels, a key factor in neurodegenerative diseases like Alzheimer's[33]. This highlights the potential for D-Asp in therapeutic applications aimed at neurological health and cognitive function.

Safety and Side Effects

While D-aspartic acid is generally considered safe for consumption, it can cause gastrointestinal discomfort when taken in excessive amounts. Common side effects include bloating, gas, and diarrhea[12]. Understanding these potential side effects is essential for individuals considering D-Asp supplementation.

References

- [1]: [Amino Acids - Aspartic Acid - The Biology Project](#)
- [2]: [Chemistry Aspartic Acid - SATHEE - Prutor](#)
- [3]: [L-Aspartic acid - Sigma-Aldrich](#)
- [4]: [L-Aspartic acid - Sigma-Aldrich](#)
- [5]: [Aspartic acid - the NIST WebBook](#)
- [6]: [Synaptic Transmission and Amino Acid Neurotransmitters](#)
- [7]: [D-Aspartic Acid benefits, dosage, and side effects - Examine.com](#)
- [8]: [L-\(+\)-Aspartic acid | C₄H₇NO₄ - ChemSpider](#)
- [9]: [Aspartic acid - Wikipedia](#)
- [10]: [Aspartic Acid - an overview | ScienceDirect Topics](#)
- [11]: [The Central Enzymes of the Aspartate Family of Amino Acid ...](#)
- [12]: [New Insight into Aspartate Metabolic Pathways in Populus - MDPI](#)
- [13]: [Amino acid synthesis - Wikipedia](#)
- [14]: [Prebiotic Synthesis of Aspartate Using Life's Metabolism as a Guide](#)
- [15]: [Non-targeted metabolomics unveils metabolic spectrum ...](#)
- [16]: [Aspartic Acid | C₄H₇NO₄ | CID 5960 - PubChem](#)
- [17]: [Review Article Role of D-aspartate on biosynthesis, racemization ...](#)
- [18]: [What is the mechanism of Aspartic Acid?](#)
- [19]: [D-aspartate acts as a signaling molecule in nervous and ...](#)

- [20]: [22.2: Biosynthesis of Amino Acids - Biology LibreTexts](#)
- [21]: [Recent Progress in Deciphering the Biosynthesis of Aspartate ...](#)
- [22]: [Saccharomyces cerevisiae aspartate biosynthesis](#)
- [23]: [Current therapeutics for Alzheimer's disease and clinical trials](#)
- [24]: [How D-Aspartic Acid Functions in the Body - Verywell Health](#)
- [25]: [Doctors Explain D-Aspartic Acid Supplements: Benefits, Risks](#)
- [26]: [What foods contain L-Aspartic Acid? - LifeLab Supplements](#)
- [27]: [Intake of Seven Essential Amino Acids Improves Cognitive Function ...](#)
- [28]: [D-Aspartic Acid: Does It Boost Testosterone? - Healthline](#)
- [29]: [What are the side effects of Aspartic Acid?](#)
- [30]: [D-aspartic Acid Supplementation Effects on Body Composition](#)
- [31]: [Amino Acid: Benefits & Food Sources - Cleveland Clinic](#)
- [32]: [Aspartic Acid - Uses, Side Effects, and More - WebMD](#)
- [33]: [d-Aspartic acid ameliorates painful and neuropsychiatric changes ...](#)