thermospermine synthase 2.5.1.79

1 Nomenclature

EC number
2.5.1.79

Systematic name
S-adenosylmethioninamine:spermidine 3-aminopropyltransferase (thermospermine synthesizing)

Recommended name
thermospermine synthase

Synonyms
ACL5 <1> (<1> gene name [4,5]) [4,5]
SAC51 <1> (<1> gene name [4]) [4]
TSPMS <1> [4]

2 Source Organism

<1> *Arabidopsis thaliana* [4,5]
<2> *Thalassiosira pseudonana* [1,2]
<3> *Arabidopsis thaliana* (UNIPROT accession number: Q9S7X6) [1,3]

3 Reaction and Specificity

Catalyzed reaction
S-adenosylmethioninamine + spermidine = S-methyl-5'-thioadenosine + thermospermine + H^+

Natural substrates and products
S S-adenosyl-L-methioninamine + spermidine <1> (<1> SAC51 is one of the key transcription factors controlling stem elongation. Plants acquire the ability to synthesize thermospermine at an early stage of evolution by horizontal gene transfer from a prokaryote [4]) (Reversibility: ?) [4]
P 5'-methylthioadenosine + thermospermine
S Additional information <1,3> (<3> isoform Acl5 is required for stem elongation [3]; <1> ACL5 is required for correct xylem specification through regulation of the lifetime of the xylem elements [5]) (Reversibility: ?) [3,5]
P ?

D. Schomburg and I. Schomburg (eds.), *Class 2–3.2 Transferases, Hydrolases: EC 2–3.2*, Springer Handbook of Enzymes S9, DOI 10.1007/978-3-642-36240-8_67,

Substrates and products

S S-adenosyl-L-methioninamine + spermidine <1,2,3> (<1> SAC51 is one of the key transcription factors controlling stem elongation. Plants acquire the ability to synthesize thermospermine at an early stage of evolution by horizontal gene transfer from a prokaryote [4]) (Reversibility: ?) [1,2,4]

P 5'-methylthioadenosine + thermospermine (<2> sole product [2]; <2> sole product, no synthesis of spermine [1])

S Additional information <1,3> (<3> isoform Acl5 is required for stem elongation [3]; <1> ACL5 is required for correct xylem specification through regulation of the lifetime of the xylem elements [5]) (Reversibility: ?) [3,5]

P ?

Specific activity (U/mg)

0.313 <2> (<2> pH 9.4, 55°C [2]) [2]

K_m-Value (mM)

0.091 <2> (S-adenosyl-L-methioninamine) [2]
0.104 <2> (spermidine) [2]

pH-Optimum

9.4-9.6 <2> [2]

Temperature optimum (°C)

55 <2> [2]

4 Enzyme Structure

Molecular weight

196000 <2> (<2> native PAGE [2]) [2]
200000 <2> (<2> gel filtration [1]) [1]

Subunits

tetramer <2> (<2> 4 * 48000, SDS-PAGE [2]; <2> 4 * 48000, calculated, x * 50000, SDS-PAGE [1]) [1,2]

5 Isolation/Preparation/Mutation/Application

Source/tissue

seedling <3> [3]
xylem <1> (<1> in the hypocotyl as well as in the inflorescence stem, ACL5 is expressed not just broadly with respect to vasculature, but specifically in the xylem vessel elements at a strictly defined developmental stage, suggesting direct involvement of ACL5 in xylem vessel differentiation. The acl5 mutant displays severe overall inhibition of the secondary growth of the vascular tis-

sues, dramatic alteration in the morphology of the vessel elements and complete lack of xylem fibers [5]) [5]

Cloning

<2> (expression in Escherichia coli) [1]
<2> (expression with His6-tag) [2]
<3> (expression in Escherichia coli) [1]

Engineering

E156D <2> (<2> besides main product thermospermine, mutant is able to synthesize some spermine [2]) [2]
Additional information <3> (<3> contrary to wild-type, seedlings of acl5-1 loss-of-function mutant do not contain thermospermine. Daily application of thermospermine onto the shoot apex partially rescues the dwarf phenotype of the mutant, while application of spermine has no effect. The acl5-1 transcript level in acl5-1 seedlings, which is much higher than the ACL5 transcript level in wild-type seedlings, is reduced by exogenous thermospermine [3]) [3]

References

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[2] Romer, P.; Faltermeier, A.; Mertins, V.; Gedrange, T.; Mai, R.; Proff, P.: Investigations about N-aminopropyl transferases probably involved in biomineralization. J. Physiol. Pharmacol., **59**, 27-37 (2008)
[3] Kakehi, J.; Kuwashiro, Y.; Niitsu, M.; Takahashi, T.: Thermospermine is required for stem elongation in Arabidopsis thaliana. Plant Cell Physiol., **49**, 1342-1349 (2008)
[4] Takahashi, T.; Kakehi, J.: Polyamines: ubiquitous polycations with unique roles in growth and stress responses. Ann. Bot., **105**, 1-6 (2010)
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