PDAT regulates phosphatidylethanolamine as transient carbon sink alternative to triacylglycerol in nannochloropsis

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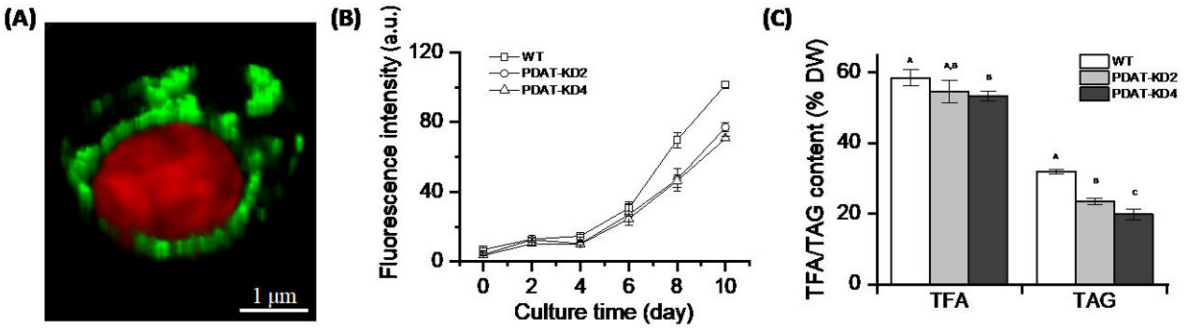


Cell localization of NoPDAT (A, green and red fluorescence are NoPDAT-eGFP fusion protein and chloroplast signal, respectively), reduction of neutral lipids (B) and changes in total fatty acid and TAG content (C), caused by NoPDAT knockdown. Credit: IHB

Nannochloropsis is a group of unicellular eukaryotes that belong to the class Eustigmatophyceae. Currently, there are seven identified species in this genus that have high photosynthetic efficiency, biomass and oil content (triacylglycerol, or TAG), and are rich in eicosapentaenoic acid (EPA), making them high-quality raw materials for the industrial production of EPA.

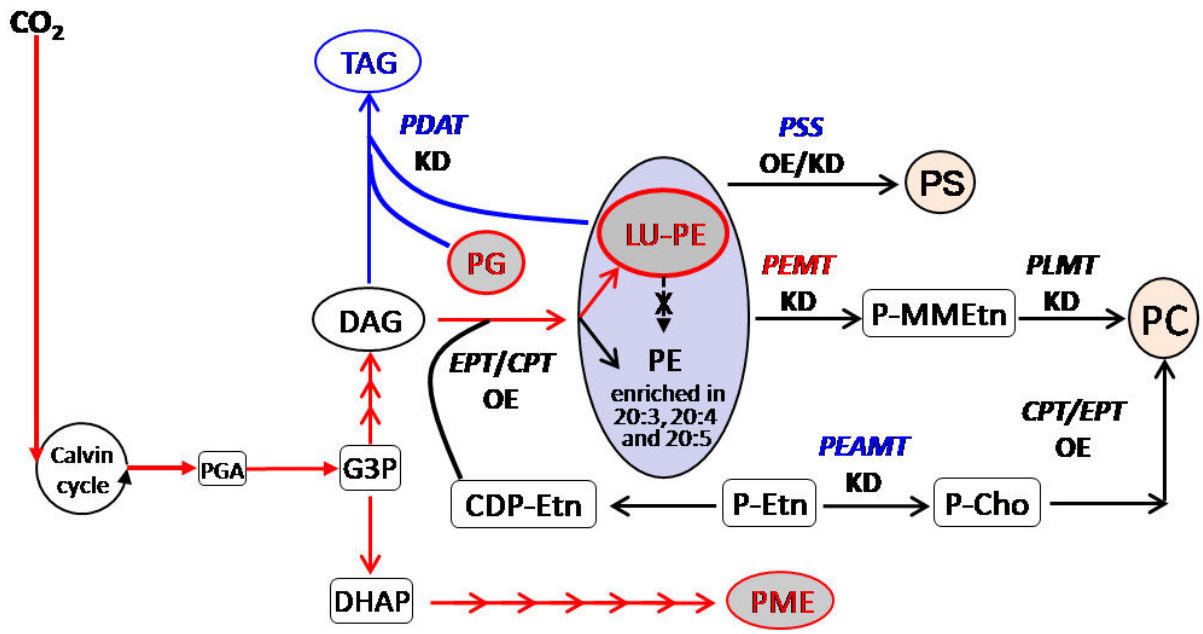
Nannochloropsis oceanica has been recognized as an industrially

important single-cell factory for lipid production because of its fast growth and high lipid content. Its genome contains up to 13 acyl CoA:diacylglycerol (DAG) acyltransferases (NoDGATs), which contribute to stress and non-stress associated TAG biosynthesis, and raises questions about whether the unique N. oceanica phospholipid:DAG acyltransferase (NoPDAT) is critical, and under what conditions and to what extent it contributes to TAG biosynthesis.

A research team led by Prof. Hu Hanhua from the Institute of Hydrobiology (IHB) of the Chinese Academy of Sciences recently addressed the function and physiological role of NoPDAT in N. oceanica. The study was published in *Plant Physiology*.

Prof. Hu's team has carried out a series of basic researches on the above-mentioned algal strains for more than ten years. They first established an efficient genetic transformation system based on polymerase chain reaction products and a gene knockdown system based on RNA interference in all the six marine species.

The researchers achieved the high-efficiency genetic transformation based on electroporation by chemical pretreatment in Nannochloropsis limnetica, the only freshwater alga in this genus.



Hypothesized working model illustrating the role of NoPDAT in lipid metabolism in N. oceanica. Credit: IHB

They found that NoPDAT resides at the outermost plastid membrane, the chloroplast endoplasmic reticulum. Based on genetic analysis, NoPDAT contributes at least 30% to TAG biosynthesis under nitrogen-limited conditions, and NoPDAT knockdown has not triggered any compensatory mechanism via DGATs.

Through the semi-quantitative thin layer chromatography analysis of polar lipids, the researchers also found that NoPDAT knockdown leads to a vast accumulation of a new class of phosphatidylethanolamines (PEs) in cells, and this special PE containing 16:0, 16:1, and 18:1 fatty acids (referred to as "LU-PE") differs from the intracellular functional PEs containing polyunsaturated fatty acids (C20:4 and C20:5).

Moreover, the content of intracellular LU-PE was significantly positively

correlated with the carbon dioxide (CO_2) concentration in culture.

Results of overexpressing and/or knockdown of genes involved in PE homeostasis indicated that LU-PE accumulation in N. oceanica is not linked to these genes and that NoPDAT is solely responsible for the observed profile change.

In summary, this study uncovers that the NoPDAT pathway is parallel to and independent of the NoDGAT pathway for oil production. LU-PE can serve as an alternative carbon sink for photosynthetically assimilated carbon in N. oceanica when PDAT-mediated TAG biosynthesis is compromised or under stress in the presence of high CO_2 levels.

More information: Juan Yang et al, PDAT regulates PE as transient carbon sink alternative to triacylglycerol in Nannochloropsis, *Plant Physiology* (2022). DOI: 10.1093/plphys/kiac160

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