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**Bacterial production of furan fatty acids**

Identification of the biosynthetic pathway and intermediates in the synthesis of furan fatty acid, providing approaches to overproduce this class of fatty acids for industrial use.

**The Science**

Fatty acids play many important roles in cells and also in industrial processes. Furan fatty acids, fatty acids which contain five membered aromatic rings with four carbon atoms and one oxygen, are present in the lipids of both prokaryotic and eukaryotic species. Furan fatty acids have numerous industrial uses and appear to function as second messengers in pathways that protect cells from membrane-damaging agents. Great Lakes Bioenergy Research Center (GLBRC) researchers have deciphered the biosynthesis of particular furan fatty acids in two species of α-proteobacteria by identifying the genes necessary and sufficient for the production of these furan fatty acids. Gas chromatography–mass spectrometry and nuclear magnetic resonance spectroscopy were used to identify the chemical structures of the products and intermediates of this pathway, and isotopic studies were conducted to determine the source of the oxygen atom in these furan fatty acids.

**The Impact**

Bacteria that produce long-chain oxygenated hydrocarbons, including furan fatty acids, provide a possible source of bioproducts that could substitute for petroleum-based lubricants, fuel and fuel additives, and more. GLBRC researchers have described a previously unknown bacterial biosynthetic pathway for furan fatty acid biosynthesis, including identification of key intermediates. These findings provide biochemical approaches to overproduce furan fatty acids for industrial use and to understand their reported roles as membrane second messengers and antioxidants. These studies also provide important new insights into the biosynthesis of furan rings, information to predict the presence of similar biosynthetic pathways, and identify genes that can be used to engineer increased production of furan fatty acids in prokaryotes and eukaryotes.

**Summary**

Fatty acids have numerous cellular and biotechnological functions. In biological membranes, fatty acids form and stabilize the hydrophobic component of the bilayer and act as a permeability barrier. Fatty acids also influence the activity of integral membrane proteins, and function as secondary messengers in signaling pathways. Industrially, fatty acids, or compounds derived from them, can serve as food additives, antioxidants, anti-inflammatory compounds, lubricants, or substitutes for other compounds that are typically derived from petroleum. GLBRC researchers are studying the biosynthetic pathway for an unusual yet important 19 carbon mono-methylated furan fatty acid, 9-(3-methyl-5-pentylfuran-2-yl)-nonanoic acid, alternatively named 10,13-epoxy-11-methyl-octadecadienoic acid (9M5-FuFA).

These researchers had previously identified a protein that was necessary for 9M5-FuFA synthesis in *Rhodobacter sphaeroides*. In work highlighted here, a methylated diunsaturated fatty acid, (10*E*,12*E*)-11-methyloctadeca-10,12-dienoic acid (11Me-10*t*,12*t*-18:2), is identified as another intermediate in 9M5-FuFA biosynthesis. Also identified are previously unknown fatty acid modifying enzymes from *Rb. sphaeroides* 2.4.1 and *Rhodopseudomonas palustris* CGA009 that synthesize 11Me-10*t,*12*t*-18:2 from 11Me-12*t*-18:1 and convert the methylated diunsaturated fatty acid into 9M5-FuFA. This work also shows that atmospheric oxygen (O2) is the source of the oxygen atom in the furan ring of 9M5-FuFA. The researchers go on to show that *Rs. palustris* produces a methyl 9-(3,4-dimethyl-5-pentylfuran-2-yl) (9D5-FuFA), which is the first published report of the synthesis of this fatty acyl chain in bacteria, and that a newly discovered protein which acts as an *S*-adenosyl methionine-dependent fatty acid methylase to synthesize diunsaturated 9D5-FuFA from the monounsaturated 9M5-FuFA.

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**Publications**

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