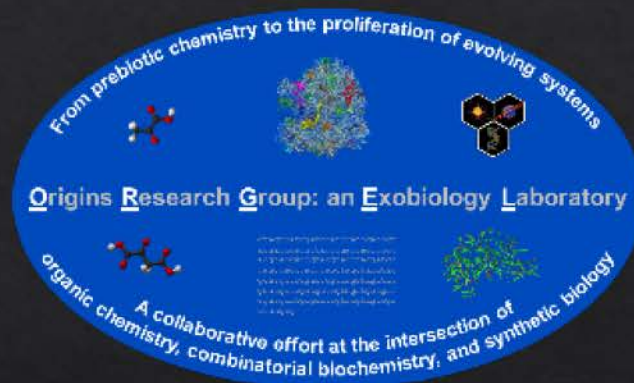
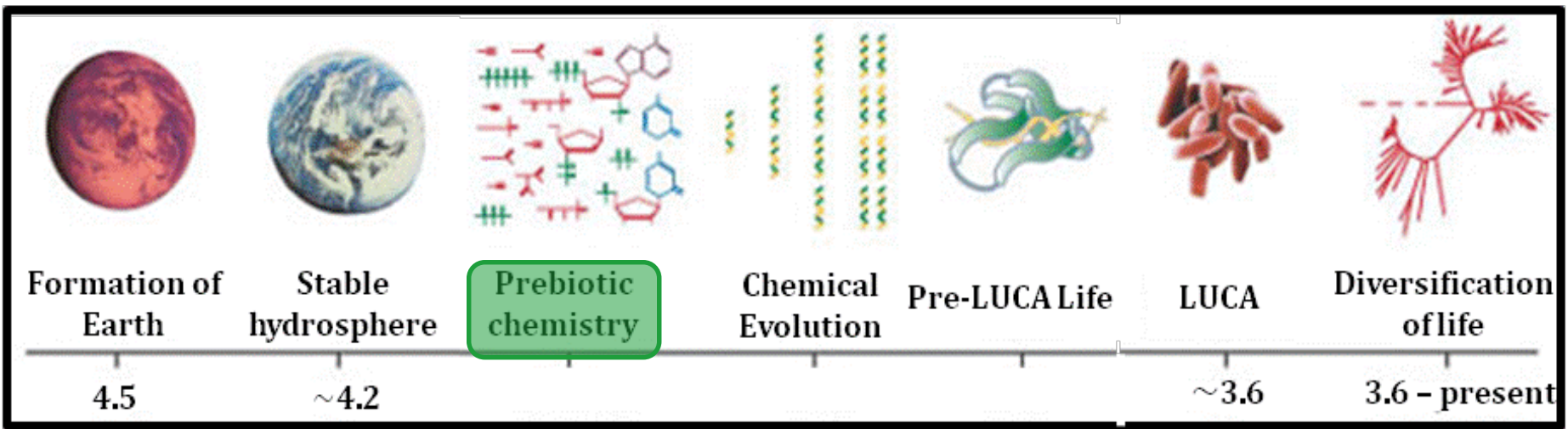


# FINDING EVIDENCE OF A PREBIOTIC PYRUVATE REACTION NETWORK IN METEORITES



Andro Rios and George Cooper\*

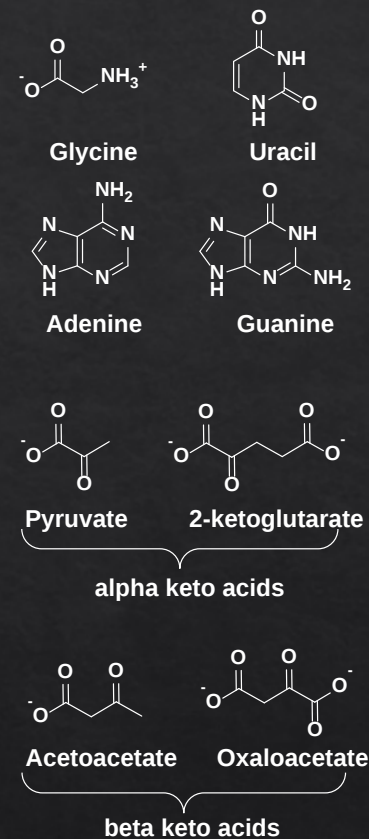
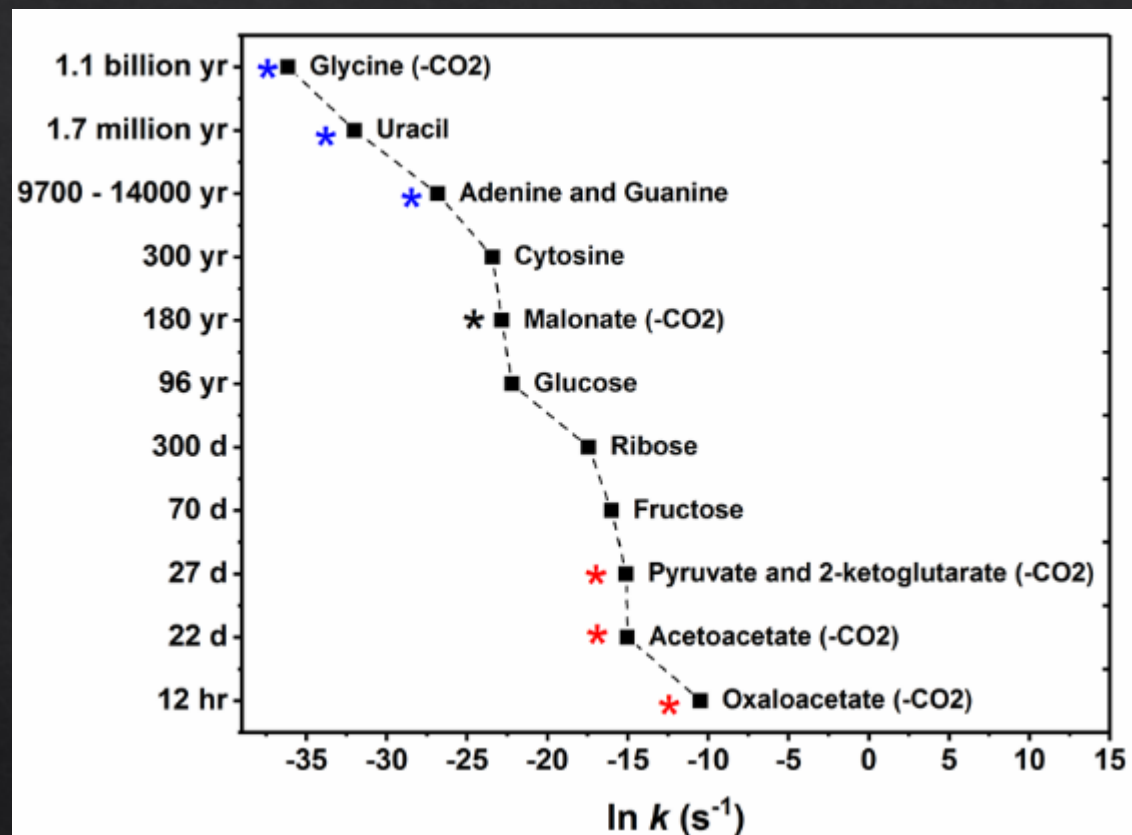
50th Lunar and Planetary Science Conference in The Woodlands, Texas



VS



# Half-lives and Decomposition Rates in water at 25°C and pH 7



Cooper *et al.* *PNAS*, **2011**, *108*, 14015.

Wolfenden, R., *Ann. Rev. Biochem* **2011**, *80*, 645

Larralde, R., Robertson, M.P., Miller, S.L. *PNAS*, **1995**, *92*, 8158

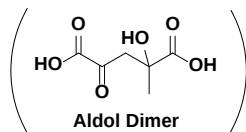


## Polymerization

Pyruvate



Aldol  
Dimer

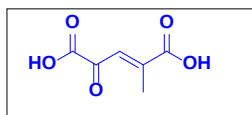


Aldol Dimer  
(Parapyruvate)

identified in Cooper et al 2011

Aldol  
Trimers

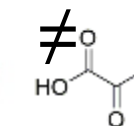
Aldol  
Tetramers



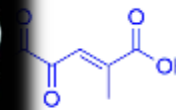
Aldol Dimer condensation product  
This work



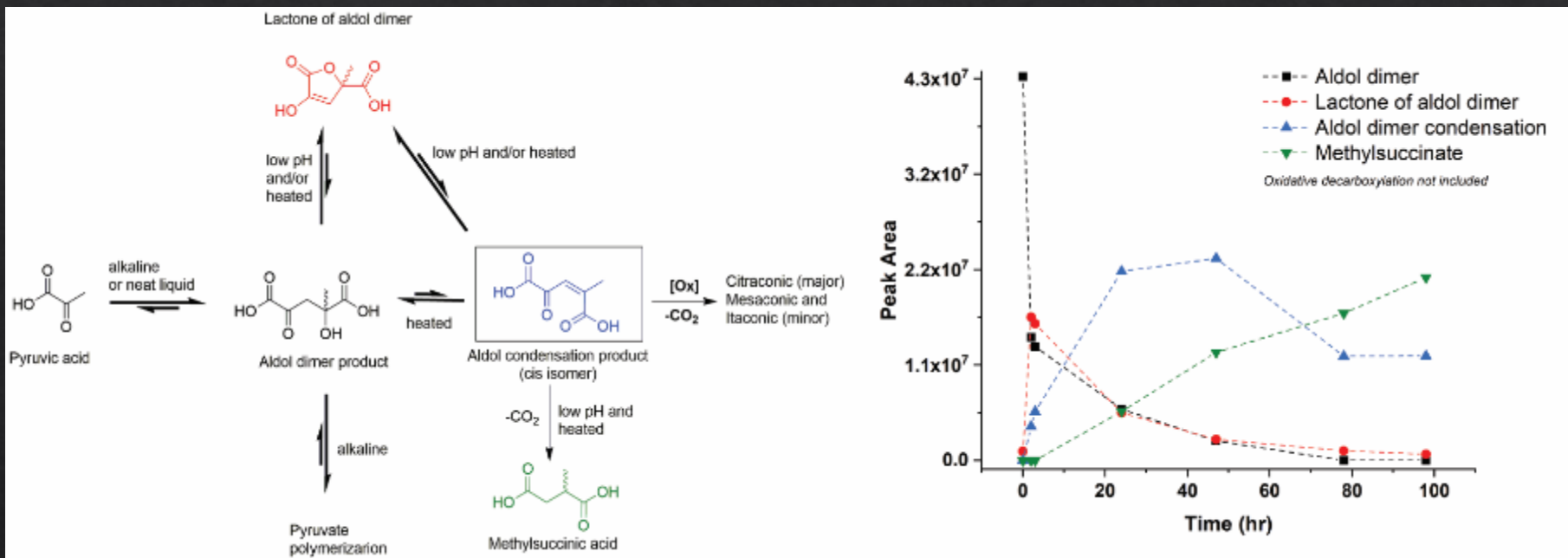
SIGMA-ALDRICH



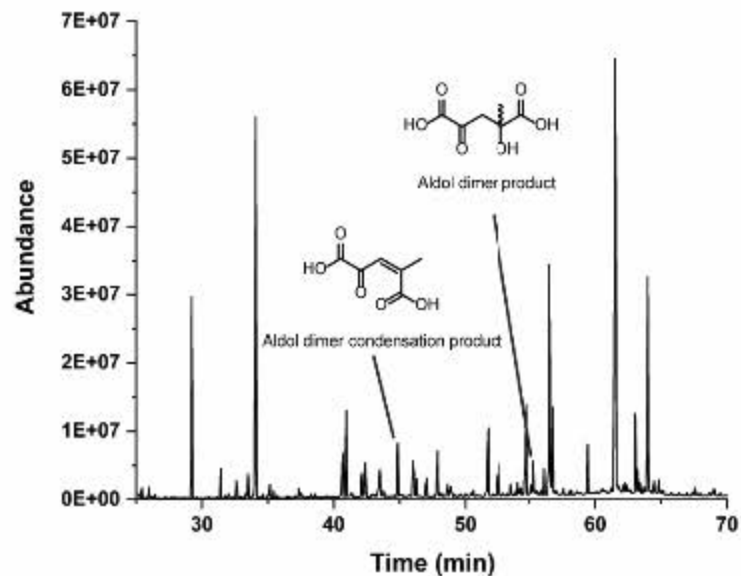
Pyruvic acid



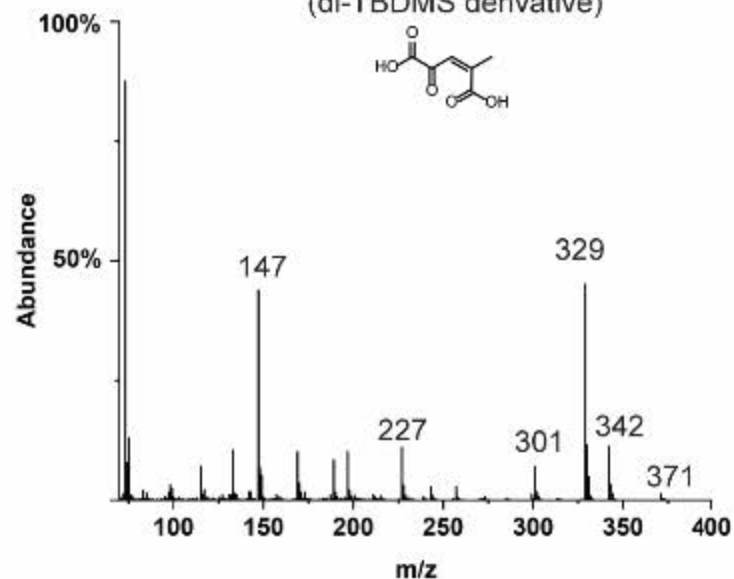
Aldol condensation product



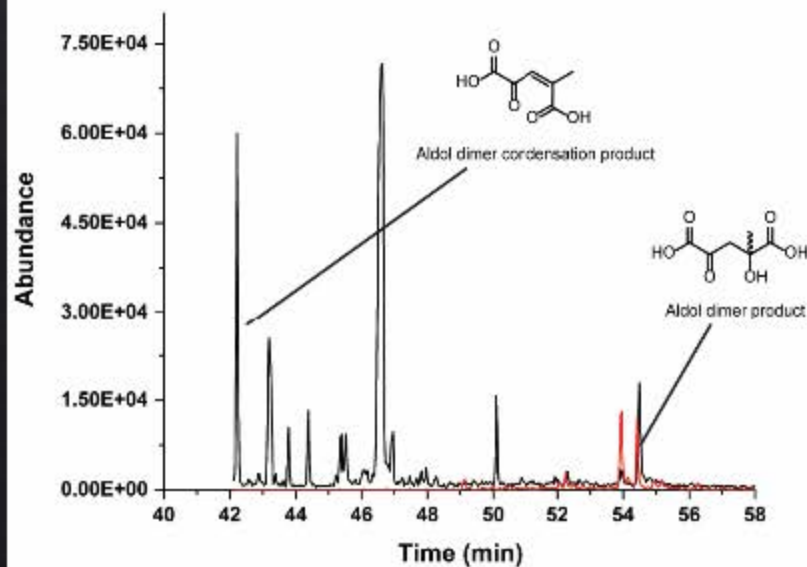
**Pyruvate Reaction Mixture (TIC:GC-MS)**



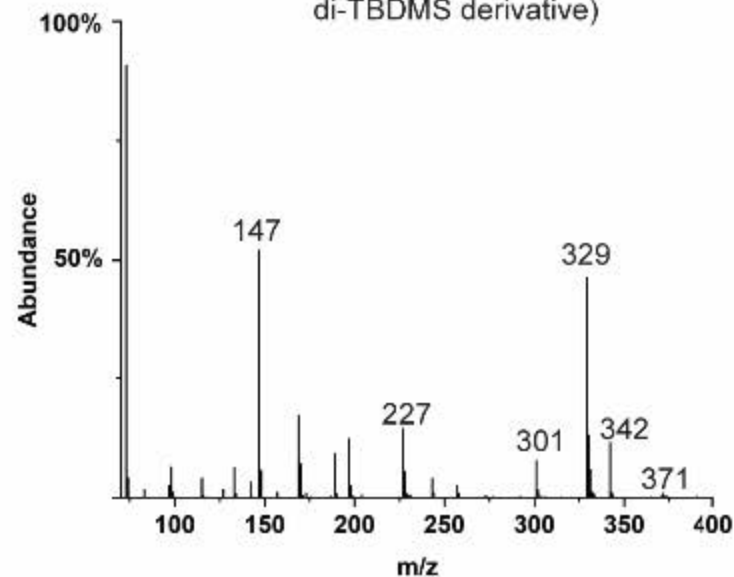
**Synthetic Standard  
(di-TBDMS derivative)**

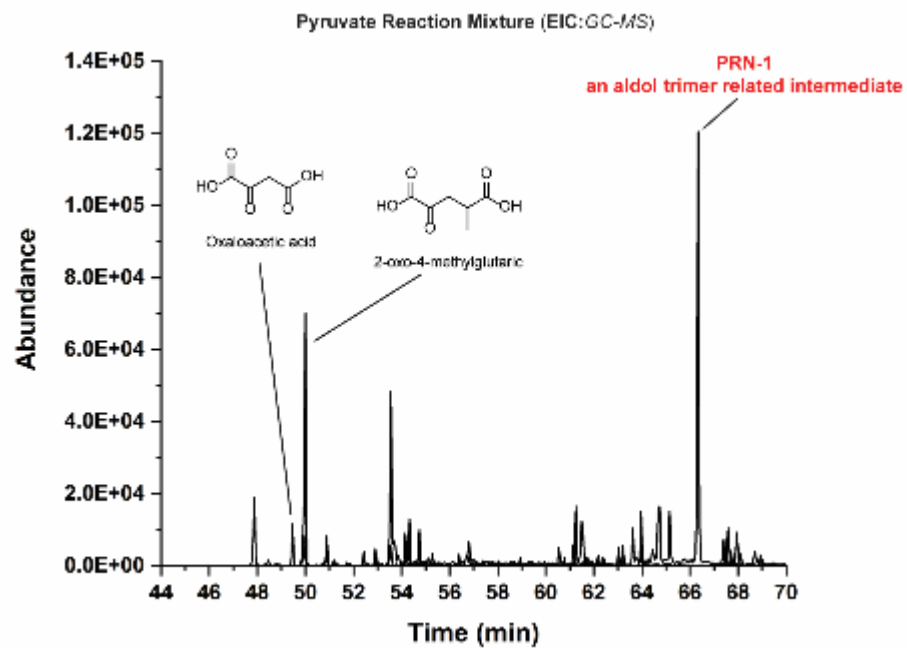
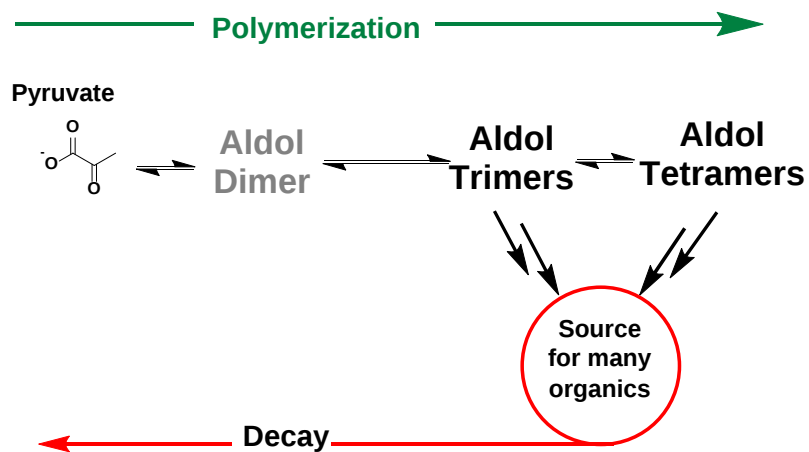


**Murch 56 (EIC:GC-MS)**

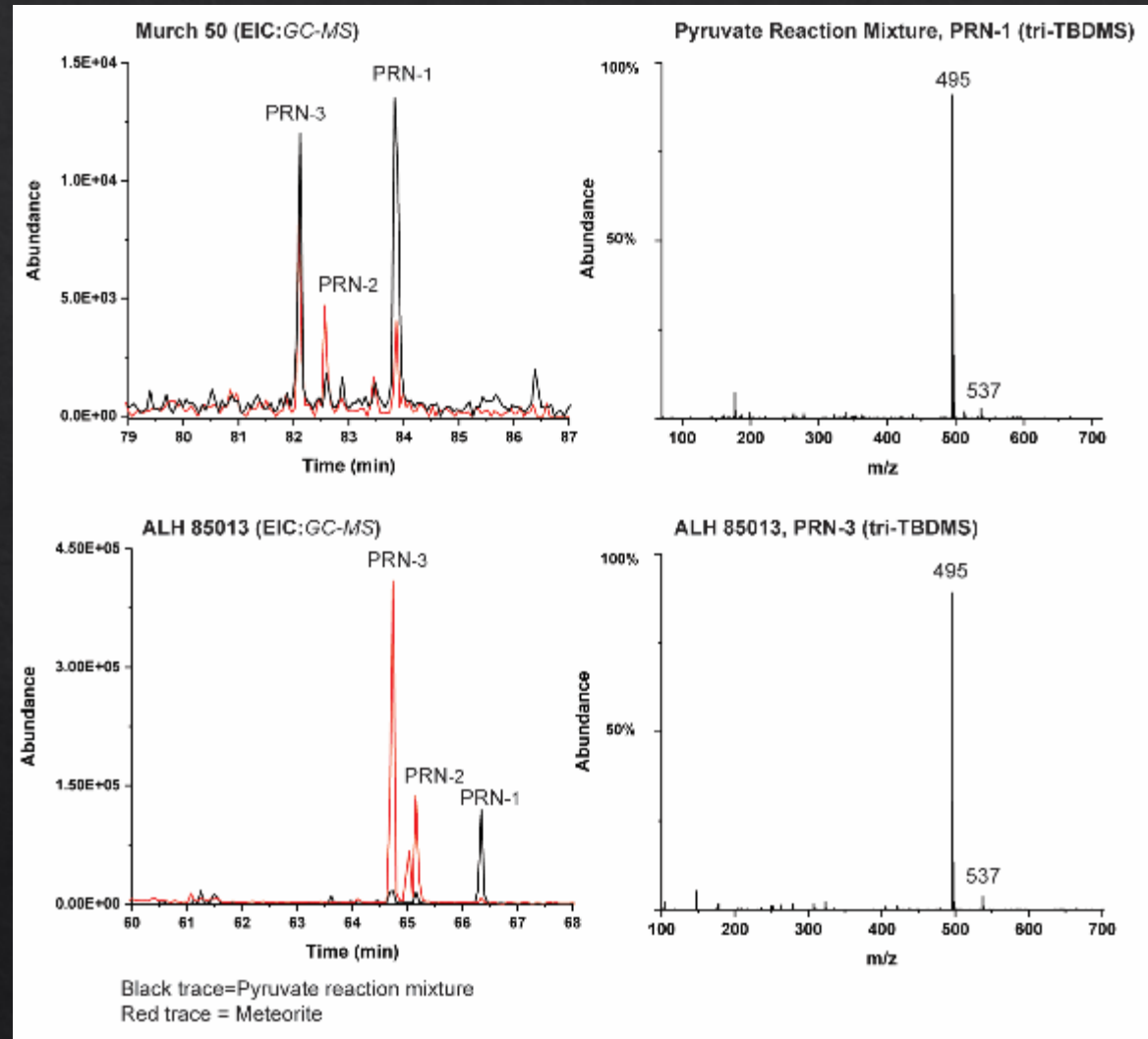
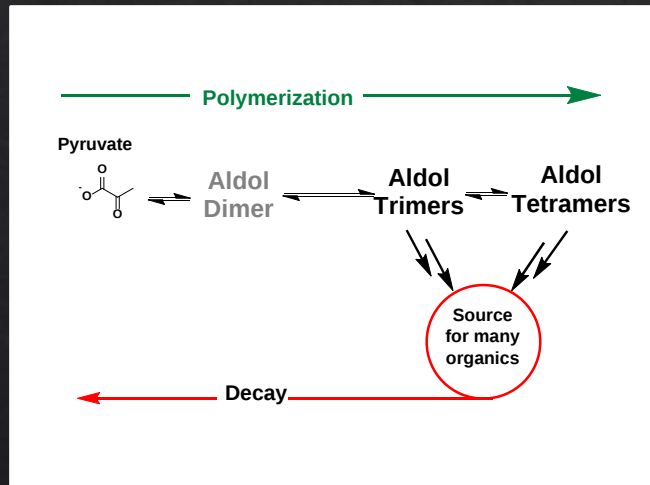


**Murch 56  
di-TBDMS derivative)**





# Isomeric Mixture of Pyruvate Polymeric Products Identified

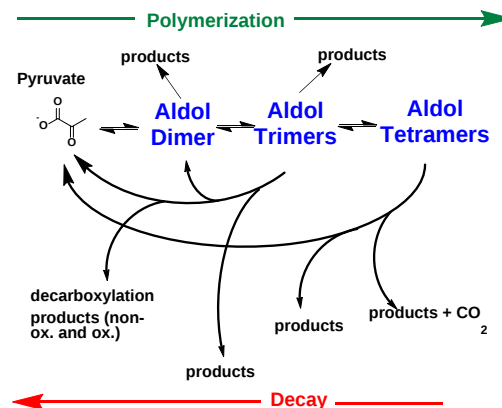


# Conclusion

- Chemical inventory of meteorites doesn't always match commercial vendor catalogs nor existing literature protocols. Thus investing in synthetic work helps drive discovery both in isolated and reaction connected meteoritic compounds.



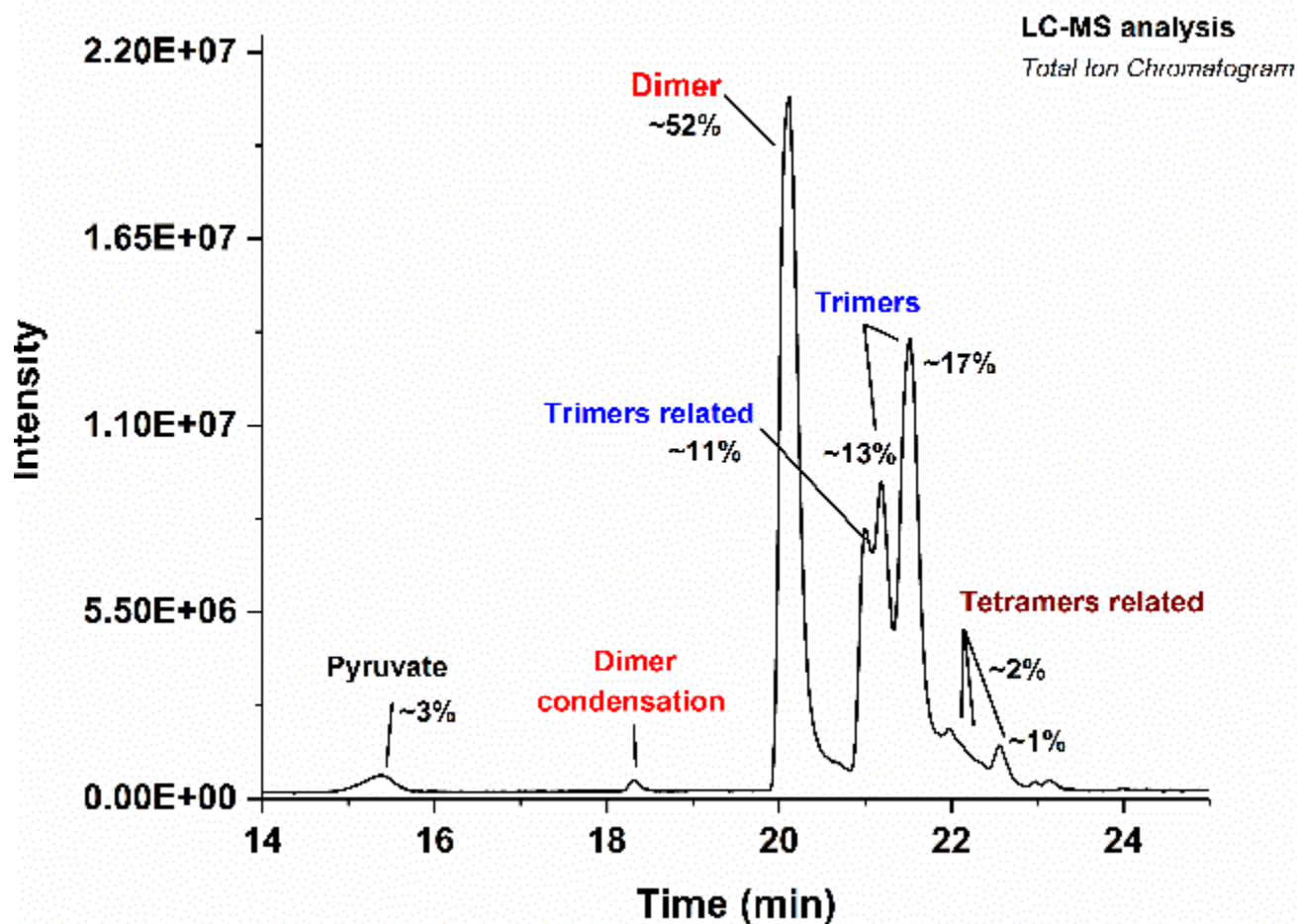
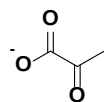
- Survival of labile keto acids (think oxaloacetate) can be explained by a reaction network based on pyruvate chemistry.



**Extra Slides**

## Polymerization →

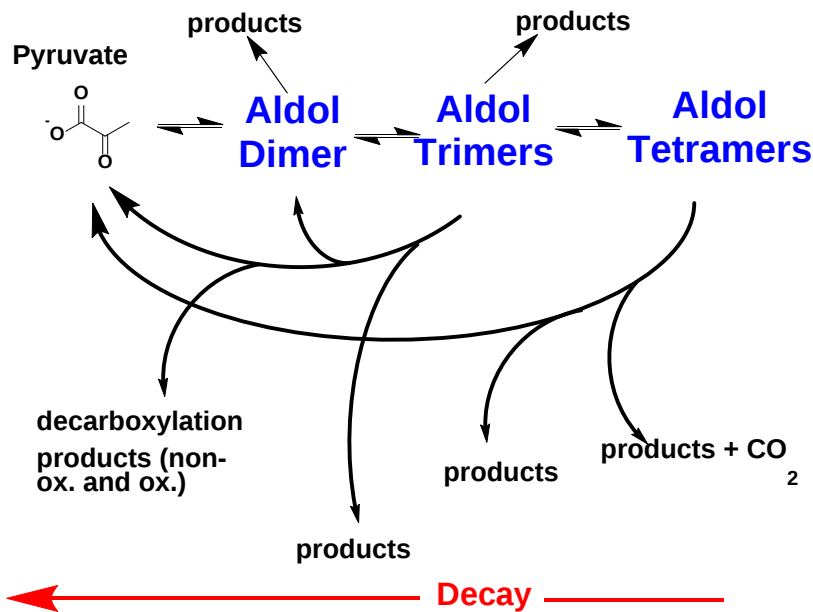
Pyruvate



### Experimental conditions:

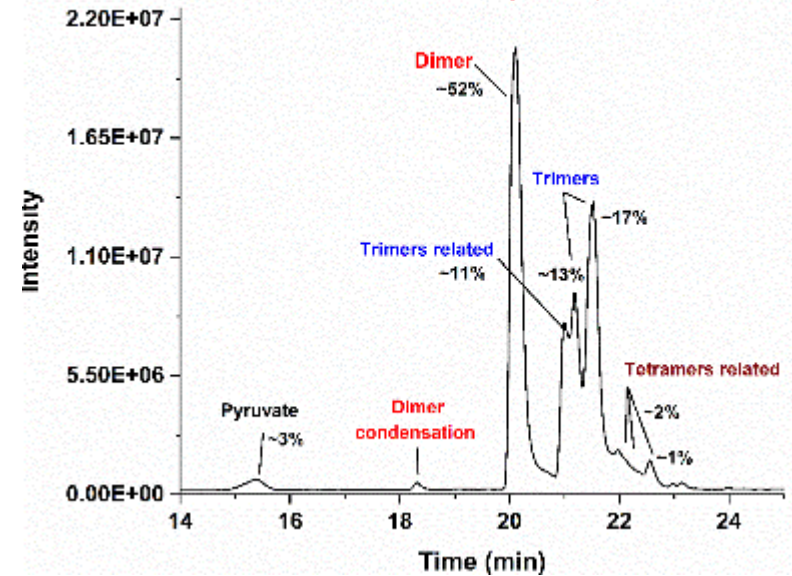
**Initial Conc:** 0.03 - 1.5 M Sodium pyruvate (aqueous), **pH:** 10.5 (Sodium carbonate buffer 0.1M), **Temp :** 22° C **Duration:** 16 days **Analysis:** LC-MS

## Polymerization



## Chromatogram of Pyruvate Aldol Reaction Products

1.5 M Sodium Pyruvate, pH 10, 25°C



## Experimental

**Conc.** 1:50 dilution of pyruvate polymeric mixture generated from an initial concentration of 1.5M sodium pyruvate reaction mixture.

**Temp:** Periodic heating of 75°C and cooling of 25°C

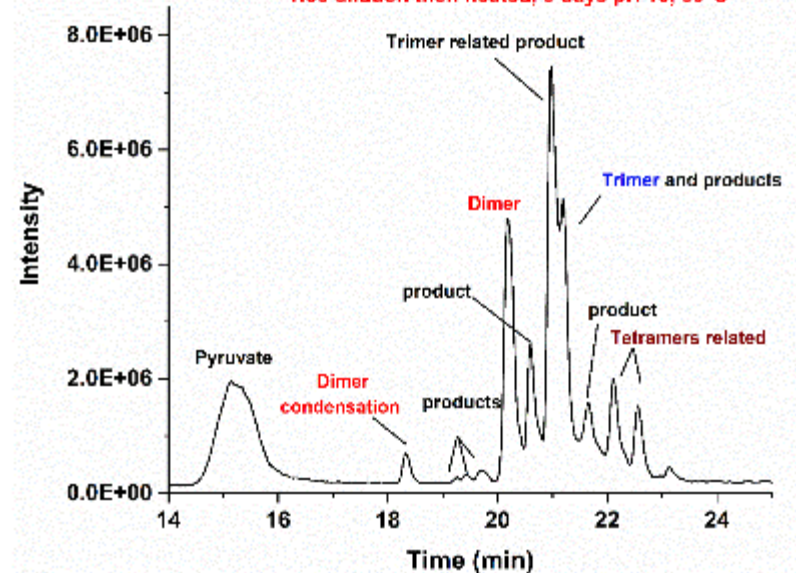
**Duration:** 3 days

**pH:** 10.5 (Sodium carbonate buffer 0.1M)

**Analysis:** LC-MS

## Heated Pyruvate Aldol Reaction Product Mixture

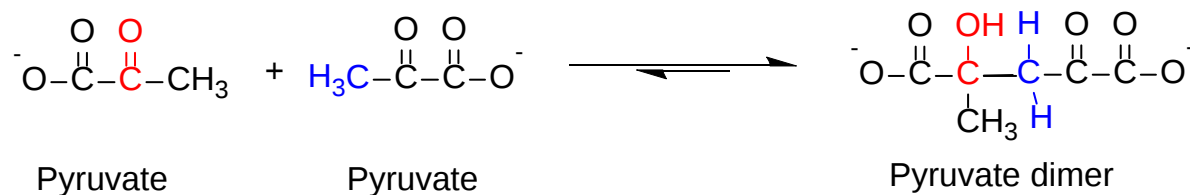
1:50 dilution then heated, 3 days pH 10, 80°C



# “Syrupy pyruvic acid”

from Berzelius, *Ann. Physik*, 1830, 36, 1

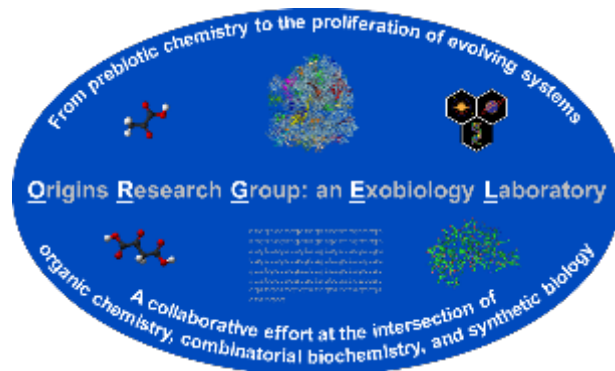
## Pyruvate aldol-type polymerization



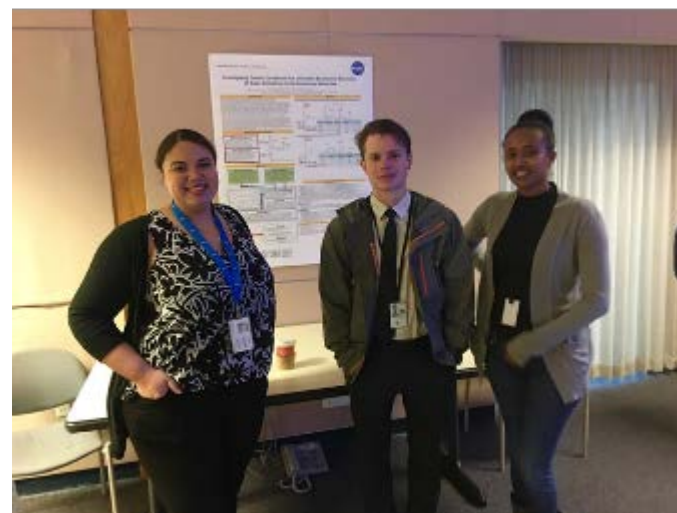
**Facile reaction across wide temperature range and wet conditions.**

Jons Jacobs Berzelius  
characterized and  
named “Pyruvic acid” in 1825





Previous Students from UC Santa Cruz:  
Melissa Thang, Samantha Yim, Yassi Mortensen, Joe  
Solvason



Sara Sorden  
*Santa  
Clara University*

Jeremy  
Lanoiselee  
*UC Santa Cruz*

Mastewal Abate  
*Notre Dame de  
Namur*