

Grignard Pure: Efficacy Data Analysis

Presentation to EPA's Office of Pesticide Programs

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Goal

To perform statistical analysis of MS2 aerosol inactivation by aerosolized Grignard Pure product.

- Question 1: is MS2 decay when exposed to Grignard Pure statistically different from natural decay at the same sampling time points?
- Question 2: what is the effective inactivation efficiency of Grignard Pure?
- Question 3: for each exposure time point, what are the hypothesized effective Grignard Pure inactivation values that are not rejected statistically ($p > 0.05$)?

Approach

- Compile all available data, including from different entities and different experiments. Select data that have same sampling/exposure times for:
 - Natural inactivation (baseline)
 - Natural inactivation + Grignard Pure
- All experiments with GP have the same sequence: Grignard Pure is introduced into MS2 aerosol.
- Grignard Pure aerosol concentration is 0.3 – 0.5 mg/m³.

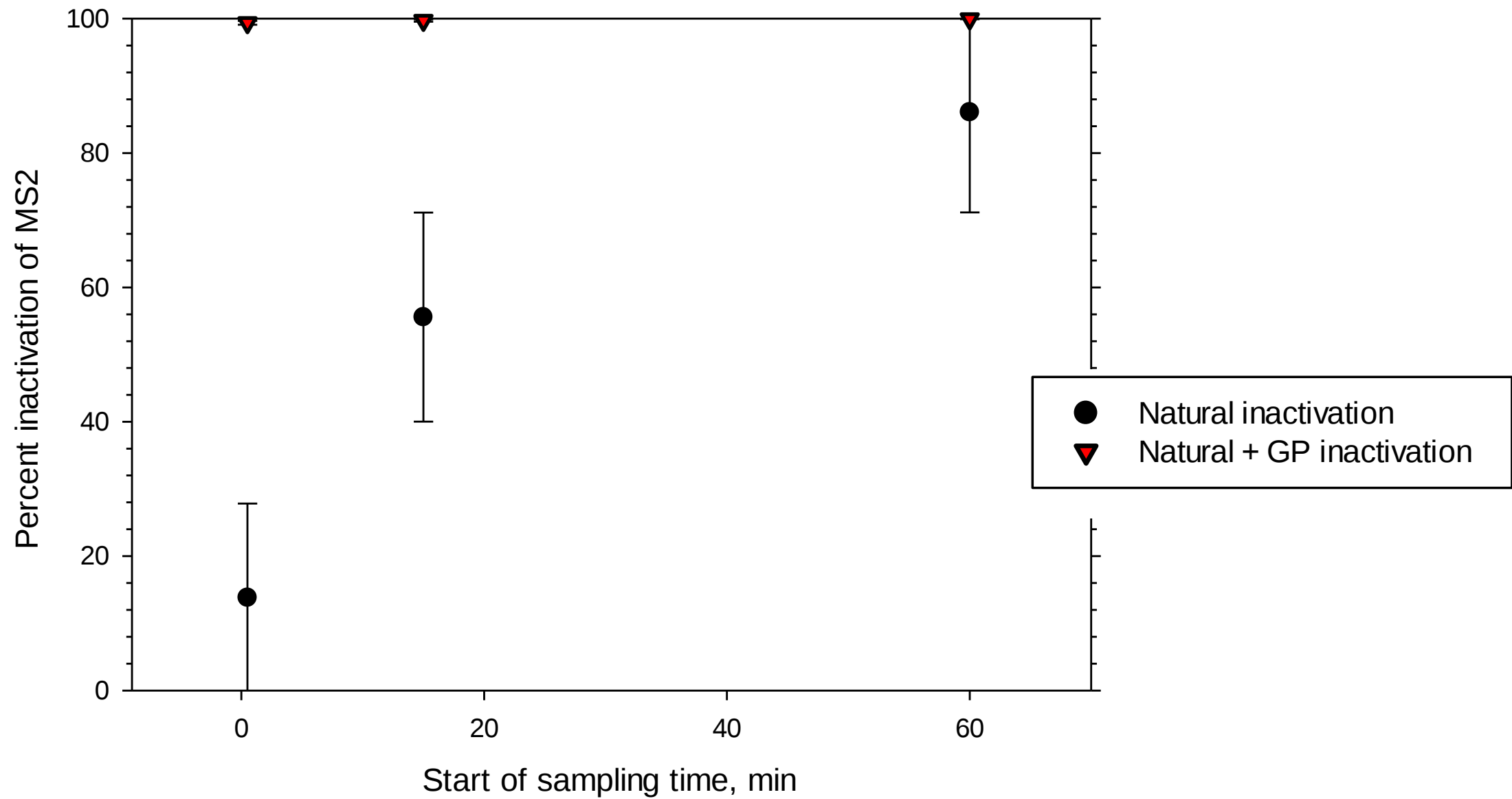
Available Data Points

Experiment	0.5 min inactivation		15 min inactivation		60 min inactivation	
	Natural	Natural+GP	Natural	Natural+GP	Natural	Natural+GP
GLP	X	X	X	X	X	X
GLP		X		X	X	X
GLP		X		X		
Test 1					X	
Test 2			X			
Test 4	X	X	X	X	X	X
Test 5	X		X		X	
Test 6	X		X		X	
ORD 1			X	X	X	
ORD 2			X		X	
<i>N</i>	<i>4</i>	<i>4</i>	<i>7</i>	<i>5</i>	<i>7</i>	<i>3</i>

*The time indicates the start of 10 min sampling

Available percent inactive data

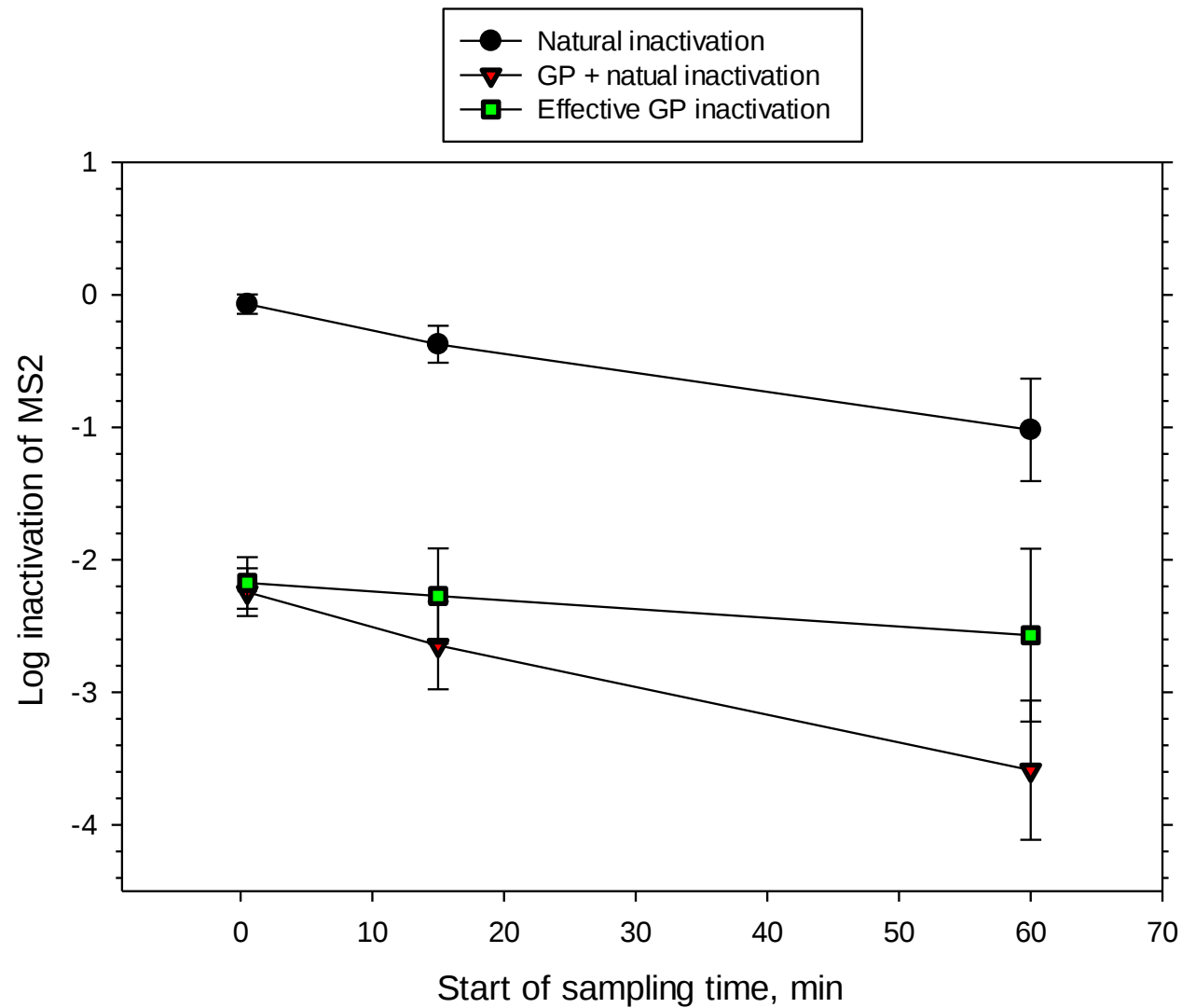
	% reduction					
	0.5 min, natural	0.5 min, natural + GP	15 min, natural	15 min, natural + GP	60 min, natural	60 min, natural + GP
	0	99.5800	54.62	99.92	86.81	99.9928
	6.89	99.5300	59.22	99.78	94.04	99.9700
	4.33	99.4900	54.85	99.69	56.62	
	29.13	98.9500	23.57	99.52	91.42	
	28.72		64.06		89.85	99.9200
			58.96		97.76	
			73.81			
Ave	13.8140	99.3875	55.5843	99.7275	86.0833	99.9609
StDev	14.0132	0.2940	15.5725	0.1676	14.9060	0.0372



The symbols are averages and error bars represent standard deviations

Approach

- Percent inactivation suggests inactivation by Grignard Pure but is not conducive to extensive statistical analysis.
- Calculate average log reduction and stdev for each time point for natural inactivation.
- Calculate average log reduction and stdev for each time point for natural inactivation + Grignard Pure.
- Calculate log effective Grignard Pure inactivation by calculating the difference between (Grignad Pure+natural) and (natural). Estimate uncertainty using partial derivatives of the resulting function. This yields uncertainty as $\text{Sqrt}(\Delta x_1^2 + \Delta x_2^2)$, where Δx_1 and Δx_2 are variables.



- For natural inactivation and natural+Grignard Pure inactivation, the symbols are averages and error bars represent standard deviations.
- For effective Grignard Pure inactivation, the symbols are resulting values (difference of the averages) and error bars are estimated errors.

Is there a statistical significance at each time point between natural and natural + Grignard Pure ?

- Two-sample t-test assuming equal variance for each set of data
 - 0.5 min: $p < 4.3 \times 10^{-8}$
 - 15 min: $p < 5.5 \times 10^{-8}$
 - 60 min: $p < 2.3 \times 10^{-5}$
- Statistically significant difference for each exposure time!
- Grignard Pure DOES have an inactivating effect on MS2.

What is the Grignard Pure effect?

- The earlier calculation was based on aggregated averages (N=1), therefore statistical testing is impossible.
- NEXT:
 - Calculate average natural reduction for each exposure time. Use it as a baseline.
 - For each exposure time and for each Natural+Grignard Pure inactivation data point, calculate the effective Grignard Pure inactivation, using the average natural reduction as baseline.
 - Now we have several Grignard Pure inactivation data points for each exposure time.

Use average natural reduction, calculate individual GP effective values

		0.5 min		15 min		60 min
	0.5 min, natural	0.5 min, Effective GP	15 min, natural	15 min, Effective GP	60 min, natural	60 min, Effective GP
Ave	-0.069	-2.307	-0.373	-2.724	-1.018	-3.124
StDev	0.073	-2.259	0.139	-2.285	0.387	-2.505
		-2.223		-2.136		-2.079
		-1.909		-1.946		
Effective GP reduction		-2.175		-2.273		-2.569
Stdev		0.180		0.331		0.525
n		4.000		4.000		3.000

Approach

- Now we can use the t-test to find out what expected values of average Grignard Pure inactivation are not statistically rejectable at $p=0.05$ level.
- Using this approach we can determine lower and upper bounds where the average effective Grignard Pure inactivation is found.
- Convert log inactivation values to % inactivation values.

Lower and upper % effective Grignard Pure
inactivation values that do not lead to the
rejection of null hypothesis

		0.5 min, Effective GP		15 min, Effective GP		60 min, Effective GP
Hyp. Lower (μ_0)		-2.385		-2.660		-3.445
t		2.335		2.334		2.888
p-value		0.0509		0.051		0.051
Hyp. Upper (μ_0)		-1.964		-1.886		-1.690
t		-2.335		-2.333		-2.897
p-value		0.051		0.051		0.051
% inactivation, lower		98.914		98.701		97.958
% inactivation, upper		99.588		99.781		99.964

Interpretation

Hypothesis: Effective GP inactivation %	Test result for exposure time		
	0.5 min	15 min	60 min
90 (-1 log)	Reject: too low	Reject: too low	Reject: too low
95 (-1.3 log)	Reject: too low	Reject: too low	Reject: too low
99 (-2 log)	Do not reject	Do not reject	Do not reject
99.5 (-2.3 log)	Do not reject	Do not reject	Do not reject
99.9 (- 3 Log)	Reject: too high	Reject: too high	Do not reject
99.95 (-3.3 log)	Reject: too high	Reject: too high	Do not reject
99.99 (- 4 log)	Reject: too high	Reject: too high	Reject: too high

Conclusions

- The data indicate reductions in airborne MS2 virus levels when exposed to Grignard Pure aerosol.
- Grignard Pure is causing a statistically significant reduction in MS2 aerosol concentrations at all three measured exposure time points (e.g., 0.5, 15 and 60 min).
- The average inactivation values are greater than 99% for all three exposure time points.
- The hypothesis that average inactivation is 99.5% (2.3 logs) is not rejected for all three exposure time points.
- The hypothesis that average inactivation is 99.9% (3 logs) is not rejected for 60 min exposure.