Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supplementary Information for An Experimental, Computational and Uncertainty Analysis Study of the Rates of Alkyl Iodide Trapping by DABCO in Solution Phase Organic Media

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Table S1 Relevant physical-chemical properties of solvents and reagents used for these experiments.

Solvent/Reagent	Class	Density @ 20 °C g/cm³	Dielectric Constant, ε	Dipole Moment, μ Debye	Viscosity mPa @20 °C	Vapor Pressure @20 °C mmHg
MeOH [1, 2]	protic	0.791	33.0	1.6	0.54	96.0
AcN [1, 2]	aprotic	0.786	37.5	3.92	0.37	74.0
DMSO [1, 2]	aprotic	1.101	46.68	3.96	1.99	0.41
Iodomethane [2]	reagent	2.2790	6.92	1.63	–	408.0
1-Iodobutane [2]	reagent	1.6076	6.35	2.10	–	10.0
DABCO [3]	reagent	1.1	-	0.0	–	1.23 @25 °C

1 E. V. Anslyn and D. A. Dougherty, *Modern Physical Organic Chemistry,* University Science Books, Mill Valley, CA, 2006.
2 J. A. Dean *Lange's Handbook of Chemistry, 15th Ed*., McGraw-Hill, Inc. New York, 1999.
3 Calculated using Advanced Chemistry Development Software, v11.02.

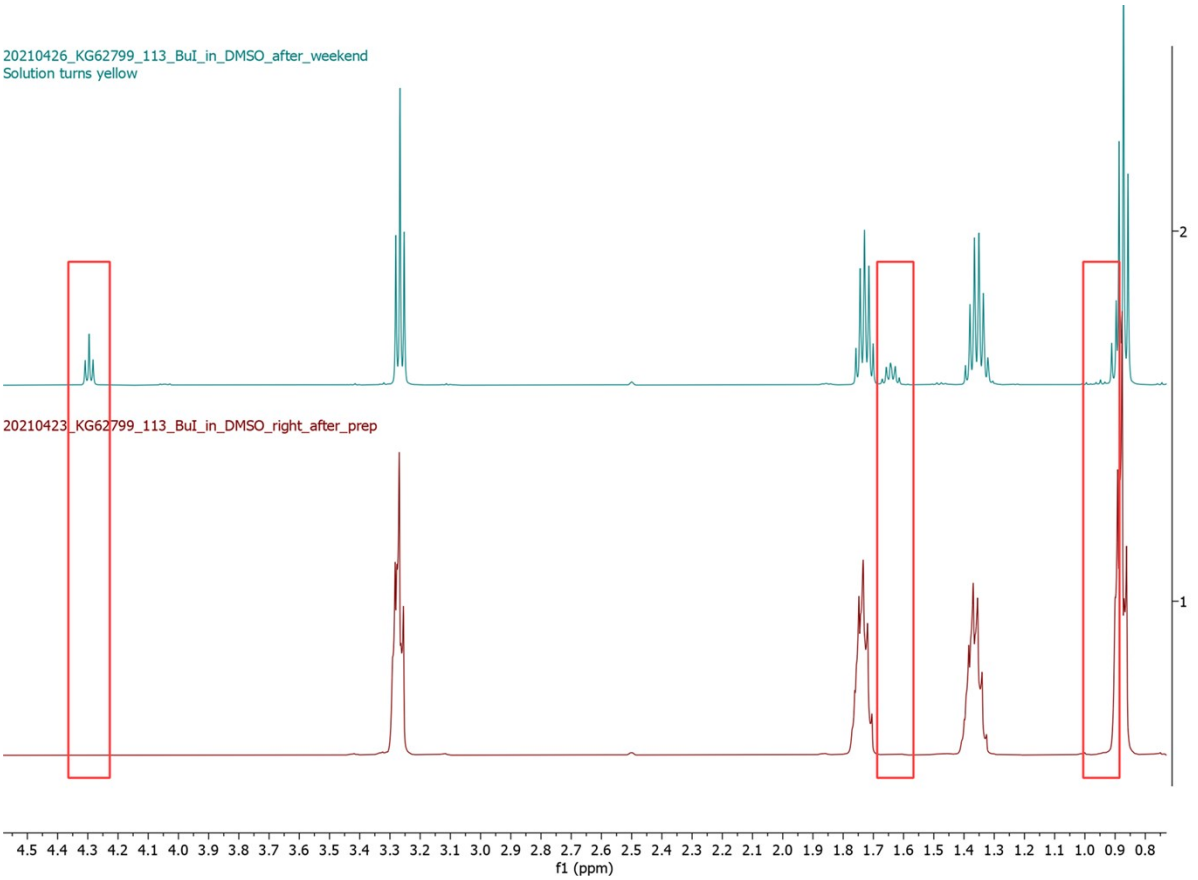

Figure S1. ^{1}H NMR spectra of a solution of DMSO-*d6* and 1-iodobutane immediately after prep (brown trace) and after about 48 hours (green trace). Spectra recorded with solution at ~ 20 °C. Spectral features of the DMSO-*d6*-1-iodobutane product are outlined in the boxes. The product was not isolated or further characterized.

Kinetic rate and uncertainty calculation for DABCO + CH_3I in CH_3OH at 55 °C.

See SUPPLEMENTARY_INFORMATION_KINETICS_PLOTS_v3.xlsx and the DABCO_MeI_CH3OH_55C worksheet for the data referred to in this analysis.

The data Segments 1, 2, and 3 were first identified by eyeball-norm judgements. The changepoints between each section could have been rigorously identified, but it was clear from the apparent continuity and smoothness of the dynamics within each Segment that the two jumps were not part of the same process.

The hypothesized jump between Segments 1 and 2 was then verified by analyzing and comparing the dynamics (rate parameters with uncertainty) of the individual Segments. The mean and standard deviation of the approximately Gaussian distribution for k_{1f} in Segment 1 suggest the mean shift in this rate to Segment 2 is significant with a p-value greater than 0.99. In other words, the shift was greater than several standard deviations with respect to the Segment 1 statistics.

With the changepoint confirmed, but no knowledge of which Segment represented the true process, the choice was made to treat each Segment as an observation of the process and statistically interpolate the results. The equations were provided in the previous e-mail.

Kinetic rate units are in $M^{-1}s^{-1}$.

Deuterated DABCO + CH_3I in CD_3OD**:**

$k_{1f} = 3.400(253) \times 10^{-2}$ (Berkeley Madonna fit $k_{1f} = 3.309 \times 10^{-2}$)

This rate was calculated using the full data set shown in SUPPLEMENTARY_INFORMATION_KINETICS_PLOTS_v3.xlsx and the DABCO_MeI_MeOD_55C worksheet.

Non-deuterated DABCO + CH_3I in CH_3OH**: (Segment 1)**

$k_{1f} = 4.568(1.159) \times 10^{-2}$ (Berkeley Madonna fit $k_{1f} = 6.0 \times 10^{-2}$)

$k_{1r} = 2.674(11.136) \times 10^{-4}$

Non-deuterated DABCO + CH_3I in CH_3OH**: (Segment 2)**

$k_{1f} = 8.062(2.086) \times 10^{-2}$ (Berkeley Madonna fit $k_{1f} = 6.0 \times 10^{-2}$)

$k_{1r} = -4.731(32.343) \times 10^{-5}$

Note: the last 3 points of the non-deuterated dataset form Segment 3, although it was not analyzed.

ANALYSIS:

In all cases, the reverse rates are negligible and statistically indistinguishable from zero.

The Berkeley Madonna fit **non-deuterated forward rate** is technically within the statistical range of both segments. However, an analysis of the rate from the two segments separately (given the 10% engineering uncertainty in the initial conditions) suggests there is a high likelihood the two segments *can be shown to be statistically distinct*. Moreover, there is a statistically significant changepoint in the

dynamics between Segments 1 and 2. If we statistically interpolate between the rates for the two segments, we get:

$$\bar{k} = \frac{\sigma_b^2}{\sigma_a^2 + \sigma_b^2} k_a + \frac{\sigma_a^2}{\sigma_a^2 + \sigma_b^2} k_b = 5.39 \times 10^{-2}$$

$$\sigma^2 = \frac{\sigma_a^2 \sigma_b^2}{\sigma_a^2 + \sigma_b^2} = 1.0264 \times 10^{-4} = \left(1.01 \times 10^{-2}\right)^2$$

So, the best approximation of the rate k_{1f} that we can make from the MCMC information given the non-deuterated dataset is 5.39(1.01) × 10^{-2} $M^{-1}s^{-1}$. The dataset is likely affected by a change that has nothing to do with the dynamics. On the other hand, it does come in range of the Berkeley Madonna fit value.

SI-DABCO-MeI-acetn-saddle-freq.txt:

```
start DABCO-MeI-acetn-saddle-freq
 title "DABCO + MeI optimisation of saddle point for first alkylation"
ecce_print "ecce-DABCO-MeI-acetn-saddle-freq.out"
memory stack 500 mb heap 100 mb global 1300 mb

charge 0
geometry units angstroms
N   -0.00003437    -0.00093629    -4.06893308
N    0.00004600     0.00088570    -1.52593138
C   -0.00022351     1.37651625    -3.56549813
H   -0.88809457     1.88745257    -3.96099176
H    0.88805691     1.88741774    -3.96008753
C   -0.00124721     1.38265532    -2.01270954
H   -0.89101768     1.88424747    -1.61024773
H    0.88652434     1.88662585    -1.60880782
C    1.19323617    -0.68885047    -3.56461071
H    1.19179850    -1.71406252    -3.95815939
H    2.07895115    -0.17432883    -3.96029233
C    1.19812717    -0.68925947    -2.01152608
H    1.18967779    -1.70957908    -1.60608936
H    2.07596495    -0.16742458    -1.60848927
C   -1.19304115    -0.68923470    -3.56453932
H   -1.19169291    -1.71413244    -3.95892237
H   -2.07901564    -0.17449946    -3.95933886
C   -1.19686169    -0.69136565    -2.01144860
H   -1.18551010    -1.71222398    -1.60745462
H   -2.07564910    -0.17226319    -1.60693238
C    0.00007903    -0.00097468     0.72509649
H   -0.93088339     0.54334046     0.61041842
I   -0.00021106    -0.00429011     3.17196738
H    0.93690523     0.53317541     0.61042978
H   -0.00588484    -1.07889131     0.60596565
end
basis
  C library aug-cc-pvdz
  H library aug-cc-pvdz
  N library aug-cc-pvdz
  I library aug-cc-pvdz-pp
end
ecp
  I library aug-cc-pvdz-pp
end

scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-acetn-saddle-freq-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; sym off; adapt off; convergence damp 45 ncydp 0 dampon 1d99 dampoff
1d-4; vectors input DABCO-MeI-acetn-saddle-freq-hf.movecs; smear; grid xfine;
iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft saddle
task dft freq
```

SI-DABCO-MeI-acetn-start-freq.txt

```
start DABCO-MeI-acetn-start-freq
 title "DABCO + MeI optimisation of starting point for first alkylation"
ecce_print "ecce-DABCO-MeI-acetn-start-freq.out"
memory stack 500 mb heap 100 mb global 1300 mb

charge 0
geometry units angstroms
 N                     0.03387337    -4.50820116    -0.01502629
 N                    -0.02463268    -1.94888945     0.02014032
 C                    -1.20754224    -4.03984925     0.61257851
 H                    -1.25415793    -4.45418310     1.62940391
 H                    -2.05400798    -4.44862358     0.04334099
 C                    -1.24136999    -2.48750633     0.63487129
 H                    -1.30318221    -2.10379825     1.66299023
 H                    -2.10585480    -2.09890125     0.07851431
 C                     0.09925970    -3.98186632    -1.38374666
 H                     1.02382986    -4.35216380    -1.84840420
 H                    -0.74974186    -4.39258677    -1.94792989
 C                     0.06240935    -2.42992060    -1.36165692
 H                     0.96717147    -2.00223354    -1.81616699
 H                    -0.80620805    -2.04310276    -1.91287608
 C                     1.17441235    -3.98693297     0.74802353
 H                     2.09685029    -4.35915035     0.28058968
 H                     1.12200200    -4.39920721     1.76536864
 C                     1.13953717    -2.43451985     0.76682750
 H                     2.04248367    -2.00983077     0.30588491
 H                     1.07285471    -2.04868410     1.79380873
 C                    -0.02433610     1.29520933     0.00131508
 H                    -0.38956437     0.98025253     0.98095768
 I                    -0.02413819     3.45740504    -0.01123052
 H                    -0.68820428     0.96927259    -0.80214950
 H                     1.00568350     0.97468249    -0.16907031
end
basis
  C library aug-cc-pvdz
  H library aug-cc-pvdz
  N library aug-cc-pvdz
  I library aug-cc-pvdz-pp
end
ecp
  I library aug-cc-pvdz-pp
end

scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-methanol-acetn-
start-freq-hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; sym off; adapt off; convergence damp 45 ncydp 0 dampon 1d99 dampoff
1d-4; vectors input DABCO-MeI-methanol-acetn-start-freq-hf.movecs; smear; grid
xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize
task dft freq
```

SI-DABCO-MeI-scan-acetn.txt

```
start DABCO-MeI-scan-acetn
 title "DABCO-MeI adduct scan to get guess for transition state in acetonitrile
solvent field"
ecce_print "ecce-DABCO-MeI-scan-acetn.out"
memory stack 500 mb heap 100 mb global 1300 mb

charge 0
geometry units angstroms
N                     0.03387337    -4.50820116    -0.01502629
N                    -0.02463268    -1.94888945     0.02014032
C                    -1.20754224    -4.03984925     0.61257851
H                    -1.25415793    -4.45418310     1.62940391
H                    -2.05400798    -4.44862358     0.04334099
C                    -1.24136999    -2.48750633     0.63487129
H                    -1.30318221    -2.10379825     1.66299023
H                    -2.10585480    -2.09890125     0.07851431
C                     0.09925970    -3.98186632    -1.38374666
H                     1.02382986    -4.35216380    -1.84840420
H                    -0.74974186    -4.39258677    -1.94792989
C                     0.06240935    -2.42992060    -1.36165692
H                     0.96717147    -2.00223354    -1.81616699
H                    -0.80620805    -2.04310276    -1.91287608
C                     1.17441235    -3.98693297     0.74802353
H                     2.09685029    -4.35915035     0.28058968
H                     1.12200200    -4.39920721     1.76536864
C                     1.13953717    -2.43451985     0.76682750
H                     2.04248367    -2.00983077     0.30588491
H                     1.07285471    -2.04868410     1.79380873
C                    -0.02433610     1.29520933     0.00131508
H                    -0.38956437     0.98025253     0.98095768
I                    -0.02413819     3.45740504    -0.01123052
H                    -0.68820428     0.96927259    -0.80214950
H                     1.00568350     0.97468249    -0.16907031
end

basis
  C library aug-cc-pvdz
  H library aug-cc-pvdz
  N library aug-cc-pvdz
  I library aug-cc-pvdz-pp
end
ecp
  I library aug-cc-pvdz-pp
end

# Geometry 1: DABCO and MeI in close proximity
geometry adjust autosym 0.1
  zcoord
    bond 2 21 3.244 "r2-21" constant
  end
end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn1-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn1-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
```

```
task dft optimize

# Geometry 2
geometry adjust autosym 0.1
  zcoord
    bond 2 21 3.0678 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn2-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn2-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 3
geometry adjust autosym 0.1
  zcoord
    bond 2 21 2.8916 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn3-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn3-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 4
geometry adjust autosym 0.1
  zcoord
    bond 2 21 2.7154 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn4-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn4-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 5
```

```
geometry adjust autosym 0.1
  zcoord
    bond 2 21 2.5392 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn5-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn5-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 6
geometry adjust autosym 0.1
  zcoord
    bond 2 21 2.3630 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn6-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn6-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 7
geometry adjust autosym 0.1
  zcoord
    bond 2 21 2.1868 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn7-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn7-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 8
geometry adjust autosym 0.1
  zcoord
    bond 2 21 2.0106 "r2-21" constant
```

```
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn8-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn8-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 9
geometry adjust autosym 0.1
  zcoord
    bond 2 21 1.8344 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn9-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn9-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3; end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 10
geometry adjust autosym 0.1
  zcoord
    bond 2 21 1.6582 "r2-21" constant
  end
end
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn10-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn10-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3;
end
driver; trust 0.1; maxiter 200; end
task dft optimize

# Geometry 11 - should be DABCO-Me+ species
geometry adjust autosym 0.1
  zcoord
    bond 2 21 1.482 "r2-21" constant
  end
end
```

```
cosmo; off; end
scf; direct; maxiter 500; vectors input atomic output DABCO-MeI-scan-acetn11-
hf.movecs; end
task scf energy
cosmo
 do_cosmo_smd true
 solvent acetntrl
 do_gasphase false
end
dft; xc pbe0; convergence damp 45 ncydp 0 dampon 1d99 dampoff 1d-4; vectors input
DABCO-MeI-scan-acetn11-hf.movecs; smear; grid xfine; iterations 100; disp vdw 3;
end
driver; trust 0.1; maxiter 200; end
task dft optimize
```