# SPECTROSCOPIC CHARACTERIZATION OF 2-NAPHTHYLCARBENE

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Abstract—The 308 nm excimer laser flash photolysis of 2-naphthyldiazomethane produces triplet 2-naphthylcarbene ( $\lambda_{max} = 362$  nm) which decays with the observed pseudo-first-order rate constants ( $k_{expel}$ ) of  $5.54 \pm 0.03 \times 10^6$ ;  $3.33 \pm 0.4 \times 10^6$ ;  $1.64 \pm 0.02 \times 10^7$ ; and  $3.05 \pm 0.4 \times 10^6$  s<sup>-1</sup> in n-pentane, 2,2,4-trimethylpentane (2,2,4-TMP), benzene and Freon 113 respectively. In hydrocarbon solvents the observed decay of triplet 2-naphthylcarbene is correlated with the pseudo-first-order growth of the 2-naphthylcarbene in 2,2,4-TMP with cyclohexane, styrene, methanol and carbon tetrachloride yielded bimolecular quenching rate constants of 1.48 \pm 0.04 \times 10^6;  $4.33 \pm 0.1 \times 10^7$ ;  $7.25 \pm 0.5 \times 10^6$ ; and  $3.35 \pm 0.07 \times 10^6$  M<sup>-1</sup> s<sup>-1</sup>. It is also found that 2-naphthylcarbene reacts with acetonitrile ( $k_q = 5.28 \pm 0.1 \times 10^5$  M<sup>-1</sup> s<sup>-1</sup>) to form a nitrile yide intermediate with a  $\lambda_{max} = 372$  nm. These results are interpreted in terms of a rapid singlet-triplet 2-naphthylcarbene equilibrium.

The recent applications of a combination of laser flash photolysis and matrix isolation techniques to the investigation of carbene state reactivity have provided data for aryl substituted carbenes that supports a mechanistic interpretation involving an equilibrium between the lowest energy singlet and triplet states and that is consistent with the tenets of the Skell-Woodworth<sup>1</sup> postulate. Measurements of the transient absorption spectra and absolute bimolecular quenching rate constants for fluorenylidene<sup>2</sup> and diphenylmethylene<sup>3</sup> have shown that these aryl substituted carbenes exhibit a mixture of singlet and triplet carbene reactivities with fluorenylidene being the more indiscriminate carbene. In the case of diphenylmethylene (DPC), competition quenching product studies and direct measurement of k<sub>st</sub> (the singlet to triplet intersystem crossing rate constant) have yielded a value of  $(5.4 \pm 1) \times 10^3$  for the equilibrium constant for the <sup>1</sup>DPC  $\neq$  <sup>3</sup>DPC interconversion.<sup>4</sup> This corresponds to a free energy difference for this process of  $-5.1\pm1$  kcal/mol. This is consistent with the earlier establishment of the triplet state as the ground state by EPR measurements.<sup>5</sup> Other spectroscopic investigations of aryl substituted carbenes including dibenzo[a,d]cycloheptatrienylidene,6 tribenzo[a,c,e]cycloheptatrienylidene7 and 10,11-dihydrodibenzo-[a,d]cycloheptadienylidene<sup>8</sup> have provided similar mechanistic pictures. Exceptions to this overall pattern of aryl carbene reactivity have only been recently observed for dimesitylcarbene<sup>9</sup> and phenyl-chlorocarbene.<sup>10</sup> Dimesitylcarbene has a geometry which increases the singlet-triplet energy gap sufficiently to prevent triplet to singlet intersystem crossing from competing effectively with reaction from the triplet state. Phenylchlorocarbene on the other hand has been shown to be a selective, ground-state singlet carbene, the halogen substituent having effectively stabilized the singlet state relative to the triplet.

Our spectroscopic investigations of the ambient temperature rearrangement of 4,5-benzocycloheptatrienylidene ( $II^{11}$  to 2-naphthylcarbene (II) (Eq. 1) have necessitated the determination of the lifetime and reactivity of triplet 2-naphthylcarbene in a variety of



solvents at ambient temperature. We report the spectroscopic characterization of triplet 2-naphthylcarbene and its absolute rates of reaction with hydrocarbons, chlorinated hydrocarbons, benzene, styrene, methanol and acetonitrile. Our results can be interpreted in terms of a rapid singlet-triplet 2naphthylcarbene equilibrium in keeping with the pattern of reactivity of fluorenylidene, diphenylmethylene, and 1-naphthylcarbene.

#### RESULTS

Excimer laser flash photolysis ( $\lambda_{ex} = 308 \text{ nm}, 15 \text{ mJ}$ ) of sublimed 2-naphthyldiazomethane in N<sub>2</sub>-purged n-pentane results in the formation of two detectable transient absorptions between 300 and 800 nm. The first of these species shown in Fig. 1(a) has a  $\lambda_{max} = 362$ nm and appears simultaneously with the laser pulse. This first species decays with an observed pseudo-firstorder rate constant of  $5.54 \pm 0.3 \times 10^6 \text{ s}^{-1}$ . Due to the partial depletion of the 2-naphthyldiazomethane whose absorption tails to 355 nm, all spectra taken at times  $\leq 1 \ \mu s$  after excitation show a characteristic negative  $\Delta OD$  in the region of 340–350 nm. The second intermediate ( $\lambda_{max} = 378$  nm, 395 nm shoulder) is seen as a shoulder in Fig. 1(a) (60 ns) and as the only species in Fig. 1(b) (300 ns). It exhibits a pseudo-first-order growth  $(k_{exptl} = 3.08 \times 10^6 \,\text{s}^{-1})$  and shows no evidence of decay within one microsecond. This long-lived species is significantly quenched by  $O_2$  and follows a pseudo-first-order decay ( $k_{expt1} = 5.13 \pm 0.07 \times 10^5 \text{ s}^{-1}$ ) in air-saturated n-pentane. The same transient ( $\lambda_{max} = 378$ nm) is observed in 2,2,4-TMP and cyclohexane but is conspicuously absent in acid washed and rigorously dried benzene. Thus our assignment of this transient as 2-naphthylmethyl radical is based on its characteristic lifetime, its reactivity, and on the agreement between

the observed spectrum and the matrix isolation spectrum of 2-naphthylmethyl radical measured by Porter and Strachan.<sup>12</sup> This assignment was confirmed by the isolation of the 2-naphthylmethyl radical coupling product, 1,2-di-(2-naphthyl)ethane, from the preparative photolysis of 2-naphthyldiazomethane in cyclohexane (vide infra).

The short-lived transient shown in Fig. 1(a) can also be observed in a variety of solvents including benzene. The observed pseudo-first-order rate constants for the decay of the 362 nm transient in 2,2,4-TMP, Freon 113 and benzene are  $3.33 \pm 0.4 \times 10^6$ ,  $3.05 \pm 0.4 \times 10^6$ and  $1.64 \pm 0.2 \times 10^7$  s<sup>-1</sup> respectively. The short-lived transient was not detected in cyclohexane, the growth of the 2-naphthylmethyl radical occurring essentially simultaneously with the laser pulse. Oxygen effectively quenches this short-lived transient. Thus the observed rate constant for decay is seen to more than double to  $8.19 \pm 0.1 \times 10^6$  s<sup>-1</sup> in air saturated 2,2,4-TMP. Based on its reactivity with oxygen, its apparent kinetic correlation with the growth of 2-naphthylmethyl radical in effective H-atom donating solvents (npentane, cyclohexane and 2,2,4-TMP), its formation within the 10 ns fwhm laser pulse and its characteristic



Fig. 1. Transient absorption spectra obtained after 308 nm excitation of 2-naphthyldiazomethane in  $N_2$ -purged n-pentane. (a) 60 ns after excitation. (b) 300 ns after excitation.

lifetime, this absorption is assigned to triplet 2naphthylcarbene. The 16 nm blue shift of the carbene absorption maximum with respect to the radical absorption is consistent with the corresponding assignments for the substituted triplet diphenyl-methylenes<sup>13</sup> and for triplet fluorenylidene.<sup>2</sup> This assignment is also corroborated by the isolation of typical triplet carbene products from the preparative photolysis of 2-naphthyldiazomethane in cyclohexane. Thus, 308 nm irradiation of a  $5.5 \times 10^{-3}$  M soln of 2-naphthyldiazomethane in N<sub>2</sub>-purged cvclohexane yields 2-(cyclohexylmethyl)naphthalene (41%), 1,2-di-(2-naphthyl)ethane (11%), cis- and trans-1,2di-(2-naphthyl)ethylene (10%), azine (5%) and 2naphthaldchyde (11%). At the low concentration used for the preparative photolysis, and at the even lower concentration used in the flash photolysis experiments  $(1.3 \times 10^{-4} \text{ M})$ , azine formation is minimized. As is expected therefore, decreasing the 2-naphthyldiazomethane concentration by a factor of four does not change the measured rate constant for decay of carbene. The small amount of 2-naphthaldehyde isolated arises from the hydrolysis of azine during the extensive chromatography required for analysis. The 1,2-di-(2-naphthyl)ethane is clearly formed by H-atom abstraction by triplet 2-naphthylcarbene followed by 2naphthylmethyl radical coupling. The 2-(cyclohexylmethyl)naphthalene has two possible origins,<sup>14</sup> one, direct C-H bond insertion by singlet 2-naphthylcarbene and two, H-atom abstraction by triplet 2naphthylcarbene followed by radical recombination. Presumably the former is the predominant pathway and the moderate yield of this product is indicative of significant singlet carbene participation.

When sublimed 2-naphthyldiazomethane is used in the laser flash photolyses, little or no fluorescent emission is observed. However, after several laser pulses, a strong fluorescence builds up ( $\lambda_{max} \cong 385$  nm,  $\tau_{f1} \cong 6$  ns in CH<sub>3</sub>CN) which can be attributed to the emission of cis- and trans-1,2-di-(2-naphthyl)ethylene.<sup>15</sup> The yield of these olefin products is dependent on the concentration of 2-naphthyldiazomethane and as a result they are produced in detectable quantities in the preparative photolyses in cyclohexane (vide supra).

A substantially different spectral and kinetic situation from that described for the hydrocarbon solvents occurs upon excitation of 2-naphthyldiazomethane in acetonitrile. Here a strongly-absorbing, long-lived species with a  $\lambda_{max} = 372$  nm is detected. The growth of this species is observed to be complete within ca 40 ns of the laser excitation (Fig. 2). The absorption spectrum of this intermediate (Fig. 3) is broad and essentially structureless extending from ca 350-420 nm. There is no spectroscopic evidence for the triplet 2-naphthylcarbene under these conditions in acetonitrile due to the very rapid formation of this new, overlapping absorption. This new transient we believe to be the nitrile ylide III. Our observations are consistent with those of Platz et al.<sup>16</sup> who have shown that photolysis of





Fig. 2. Transient absorption obtained at 362 nm following 308 nm excitation of 2-naphthyldiazomethane in  $N_2$ -purged acetonitrile.



Fig. 3. Transient absorption spectrum obtained 800 ns after 308 nm excitation of 2-naphthyldiazomethane in N<sub>2</sub>-purged acetonitrile.

1-naphthyldiazomethane in a variety of nitriles produces nitrile ylides having characteristic strong absorptions with  $\lambda_{max} \cong 390$  nm. Moreover, the reactivity of this transient is characteristic of previously observed nitrile ylides.<sup>17,2</sup> For example, the ylide shows no evidence of decay within 1  $\mu$ s of its formation either in N<sub>2</sub>-purged or air-saturated acetonitrile. However, introduction of  $1.0 \times 10^{-2}$  M diethyl maleate completely quenches the ylide absorption.

H-atom abstraction by triplet 2-naphthylcarbene appears to compete with ylide formation in acetonitrile. Evidence for this is the appearance in the ylide spectrum of the 378 nm absorption characteristic of 2naphthylmethyl radical. An analogous situation exists for fluorenylidene.<sup>2</sup>

Our preliminary investigations showed that triplet 2naphthylcarbene had the longest lifetime and strongest absorption in those hydrocarbons having the highest branching and therefore the largest ratio of primary to secondary or tertiary hydrogens. Presumably this is related to the decreased ability of aryl methylenes to insert into primary C—H bonds.<sup>14,18</sup> We have therefore used 2,2,4-trimethylpentane as a moderately "inert" solvent for the determination of the bimolecular quenching rate constants for the reaction of 2naphthylcarbene with cyclohexane, acetonitrile, methanol, styrene and carbon tetrachloride. For these substrates the bimolecular rate constant was obtained from the slope of a plot of k<sub>exptl</sub> vs the concentration of the quenching species, where k<sub>exptl</sub> is the pseudo-firstorder rate constant for triplet 2-naphthylcarbene decay. The rate constant data are summarized in Table 1.

The quenching rate constant for the reaction of 2naphthylcarbene with acetonitrile is measured at low concentrations of acetonitrile to be  $5.28 \pm 1 \times 10^5 \text{ M}^{-1} \text{ s}^{-1}$  at 297 K. This value is similar to that measured for

Table 1. Bimolecular quenching rate constant data for the reaction of 2-naphthylcarbene<sup>a</sup> with various substrates at 24° in 2,2,4-trimethylpentane

Substrate*	Monitoring λ, nm	k <sub>q</sub> , M <sup>-1</sup> s <sup>-1 d</sup>
cyclohexane	362 <sup>b</sup>	$1.48 \pm 0.04 \times 10^{6}$
cyclohexane	378°	$7.96 \pm 0.4 \times 10^{5}$
styrene	362	$4.33 \pm 0.1 \times 10^7$
methanol	362	$7.25 \pm 0.5 \times 10^{6}$
carbon tetrachloride	362	$3.35 \pm 0.07 \times 10^{6}$
acetonitrile	362	$5.28 \pm 0.1 \times 10^{5}$

\*[2-Naphthyldiazomethane] =  $1.31 \times 10^{-4}$  M in N<sub>2</sub>purged 2,2,4-TMP,  $\lambda_{ex} = 308$  nm.

<sup>b</sup>  $\lambda_{max}$  of triplet 2-naphthylcarbene.

 $^{\circ}\lambda_{max}$  of the 2-naphthylmethyl radical.

<sup>d</sup> All bimolecular rate constants were obtained from the slope of a plot of  $k_{exptl}$  vs [quencher] where  $k_{exptl}$  is the pseudo-first-order rate constant for 2-naphthylcarbene decay or 2-naphthylmethyl radical growth. The errors represent one standard deviation.

•At concentrations of  $CH_3CN$  less than 0.4 M, the ylide absorption at 362 nm is negligible when compared to the triplet 2-naphthylcarbene absorption. the growth of ylide ( $k_q = 4.6 \pm 0.2 \times 10^5 M^{-1} s^{-1}$ ) in the laser flash photolysis of 1-naphthyldiazomethane in benzene solutions of acetonitrile.<sup>19</sup> The carbene multiplicity responsible for the production of the nitrile ylide cannot be ascertained from these experiments. The seemingly most favorable pathway for ylide formation would involve back intersystem crossing from triplet to singlet 2-naphthylcarbene followed by reaction from the singlet state. However, a spinforbidden reaction between the triplet 2-naphthylcarbene and acetonitrile cannot be ruled out when one considers the observed slow quenching rate constant.

The quenching of triplet 2-naphthylcarbene by hydrocarbon solvents, e.g. cyclohexane, affords two modes for monitoring the quenching process. A pseudo-first-order quenching plot obtained by monitoring the rate of disappearance of carbene ( $\lambda_{max} = 362$  nm) in the presence of cyclohexane is shown in Fig. 4(a). Alternatively the pseudo-first-order growth of the 2-

naphthylmethyl radical can be monitored at 378 nm. A quenching plot measured by this second method is shown in Fig. 4(b). The quenching rate constant measured by these methods includes contributions from both direct triplet 2-naphthylcarbene reaction and also reverse intersystem crossing followed by rapid singlet carbene reaction. They therefore do not represent absolute rate constants for H-atom abstraction by triplet 2-naphthylcarbene.

The largest quenching rate constants measured were those for styrene, methanol and carbon tetrachloride (Table 1). Singlet 2-naphthylcarbene participation is anticipated to predominate in these reactions. However, these values are more than an order of magnitude smaller than those observed for the same reactions of fluorenylidene.<sup>20</sup> Thus 2-naphthylcarbene appears to be intermediate in reactivity to fluorenylidene and diphenylcarbene and similar to 1naphthylcarbene.



Fig. 4. Pseudo-first-order quenching plots for the reaction of 2-naphthylcarbene with cyclohexane in N<sub>2</sub>-purged 2,2,4-trimethylpentane. (a) Monitoring  $\lambda = 362 \text{ nm} (\lambda_{max} 2\text{-naphthylcarbene})$ . (b) Monitoring  $\lambda = 378 \text{ nm} (\lambda_{max} 2\text{-naphthylmethyl radical})$ .

### DISCUSSION

The solution phase chemistry of photochemically generated monoarylcarbenes has been well characterized.<sup>20</sup> The bulk of the experimental data is consistent with a mechanism in which the rates of singlet and triplet carbene reactions are comparable to the rate of equilibration of the two states. Thus, the direct and sensitized photolyses of substituted phenyldiazomethanes usually result in identical product ratios.<sup>21</sup> A similar pattern of reactivity is anticipated for photochemically generated 2-naphthylcarbene. The ground state of 2-naphthylcarbene has been identified as a triplet by EPR, and its matrix chemistry has been characterized.<sup>22</sup>

Our spectroscopic characterization of triplet 2naphthylcarbene in hydrocarbon solvents at ambient temperature and the isolation of both H-atom abstraction and C—H bond insertion products from its reaction in cyclohexane are compatible with a state equilibrium which is displaced toward the triplet.

The measurement of bimolecular quenching rate constants between  $2 \times 10^6$  M<sup>-1</sup> s<sup>-1</sup> and  $5 \times 10^7$  M<sup>-1</sup> s<sup>-1</sup> for the reaction of 2-naphthylcarbene with carbon tetrachloride, methanol and styrene suggest that it is a more discriminate carbene than fluorenylidene. While the rapid reactions of aryl carbenes with methanol and styrene have been discussed extensively,<sup>23</sup> the rapid quench of 2-naphthylcarbene by carbon tetrachloride is intriguing. Presumably the quenching mechanism could involve either chlorine atom abstraction by the singlet<sup>24</sup> or triplet<sup>25</sup> carbene or alternatively by initial halonium ylide formation<sup>26</sup> followed by collapse to insertion products. Our current spectral and kinetic data do not distinguish between these mechanisms.

The quenching of 2-naphthylcarbene by cyclohexane results in the formation of products indicative of triplet carbene reaction (1,2-di-(2-naphthyl)ethane) and also the singlet carbene C-H insertion product, 2-(cyclohexylmethyl)naphthalene. A portion of this latter product could also arise from triplet H-atom abstraction followed by radical pair recombination. Less likely sources of this latter product would be excited singlet carbene<sup>26</sup> or excited singlet 2naphthyldiazomethane.<sup>25,27</sup> Since we are barely able to spectroscopically detect the triplet 2-naphthylcarbene upon direct laser flash photolysis of 2naphthyldiazomethane in cyclohexane, we believe singlet C-H insertion is the predominant quenching mechanism and that the quantum yield for 2-naphthylmethyl radical formation is low. The integrated rate expressions for the decay of triplet 2naphthylcarbene and the growth of 2-naphthylmethyl radical (assuming a rapid singlet-triplet carbene equilibrium), both give  $k_{q(expt]} = k_{R} + k_{S}/K_{eq}$ , where  $k_{q(expt)}$  is the measured quenching rate constant (1.48  $\times 10^6 M^{-1} s^{-1}$ ),  $k_R$  is the rate constant for radical formation from triplet carbene, ks is the rate constant for singlet carbene reaction and Keg is the equilibrium constant for the singlet-triplet equilibrium. Clearly, based on the isolated radical coupling product 1,2-di-(2-naphthyl)ethane (11%),  $k_R$  must be comparable to  $k_s/K_{eq}$ . While it seems reasonable to assign  $k_s$  (C—H insertion) as approaching the diffusion controlled limit and thereby establish a lower limit for  $K_{eq}$ , no solution phase data<sup>28</sup> are available for the rates of aryl carbene C-H insertion reactions to validate this assumption.

#### **EXPERIMENTAL**

General. M.ps were determined with a Buchi capillary m.p. apparatus and are uncorrected. NMR spectra were recorded on either a Varian EM-360 60 MHz spectrometer or a Bruker AM300 300 MHz FT instrument. Low resolution mass spectra were obtained on a Hewlett-Packard Model 5985 mass spectrometer. IR spectra were recorded on a Perkin-Elmer 727B IR spectrometer.

Materials. Spectrophotometric grade solvents (acetonitrile, 2,2,4-TMP and cyclohexane) were distilled over calcium hydride under N<sub>2</sub> prior to use. Benzene was washed with H<sub>2</sub>SO<sub>4</sub>, NaHCO<sub>3</sub> aq, and water, dried and then distilled from LAH under N<sub>2</sub>. Styrene was washed with NaOH aq, dried, chromatographed through basic alumina, and vacuum distilled over LAH within 24 hr of its use. MeOH was dried and distilled from BaO. CCl<sub>4</sub> and Freon 113 were distilled from K<sub>2</sub>CO<sub>3</sub>. 2-Naphthyldiazomethane was prepared as described previously.<sup>29</sup> Samples of 2-naphthyldiazomethane were prepared for flash photolysis by sublimation of the initially crystallized diazomethane at 0.2 Torr and temps between 30 and 45° (caution! while no explosions or deflagrations were encountered, all sublimations were carried out behind an explosion shield). The sublimed 2-naphthyldiazomethane had a m.p. of 44-45° (with gas evolution).

Apparatus. The excitation source for the laser flash photolyses is a Quanta Ray EXC-1 excimer laser which produces 4–10 ns fwhm pulses of up to 20 mJ at 308 nm. The excitation energy can be varied using either suitable neutral density filters or by regulating the high voltage discharge. The beam shape and size is controlled by a  $1\frac{1}{2}$  inch by 6 inch focal length cylindrical lens. The beam is not focused in the sample.

The probe source consists of a United States Scientific Instruments CP-3 Xenon flashlamp and model MCP-3 trigger module operated in pulsed mode with a controlled highvoltage, capacitive discharge. The monitoring beam is approximately 2 × 3 mm and is arranged in a perpendicular orientation to the excitation source. The probe beam is monitored with a 1P28 photomultiplier tube (only four dynodes used) mounted on an Oriel Model 7240 1/4 meter monochromator. Timing among the laser excitation pulse, the probe beam and the detection system is achieved through a Model 113 DR digital delay generator (California Avionics Lab., Inc.). All transient pulses are digitized by a Tektronix 7912 AD transient digitizer (7A19 vertical amplifier, 7B90P timebase) which is interfaced to a Hewlett Packard 9816 microcomputer (16 Bit IO, 32 Bit internal). This allows for rapid processing and storage of the data and provides hard copy graphics capabilities. Each trace is also displayed on a NEC 11" TV monitor.

Laser pulse energies are monitored with a Laser Precision Corp. RKP 314 energy head and are usually in the range of 15 mJ. While the pulse to pulse energy reproducibility of the EXC-1 laser when operated in a single shot mode is  $\pm 5\%$ , a Hamamatsu S1226-5BQ silicon photodiode is used to monitor a reflection of the excitation beam (~2% reflection from the front face of a suprasil quartz slide) in order to normalize the pulses for spectral purposes. The routine time resolution of the instrument is from 10 ns to 1  $\mu$ s.

The samples are contained in  $10 \times 10$  mm (3 ml) quartz fluorescence cuvettes which are fitted with a stopcock for introduction of the sample and N<sub>2</sub>-purging.

Two to three traces are signal averaged at each wavelength for the spectra and samples are changed prior to the observation of a 5% decrease in optical density at a given wavelength. For kinetic measurements, 3-10 traces are averaged.

# Preparative photolysis of 2-naphthyldiazomethane in cyclohexane

Sublimed 2-naphthyldiazomethane (92 mg, 5.5 mmol) was dissolved in 100 ml of cyclohexane in a quartz tube at 24°. This soln was purged with N<sub>2</sub> and irradiated with 308 nm light (excimer laser, xenon chloride,  $\sim 1$  Hz rep. rate) for 9 hr. The

resulting yellow soln was concentrated *in vacuo* to yield 94.6 mg of a yellow solid. The product was dissolved in 6 ml of CHCl<sub>3</sub> at reflux and transferred to a silica gel gravity column prepared in hexanes. The product was eluted using a series of eluants in succession (hexanes, 50% EtOAc/hexanes, 100% EtOAc, CH<sub>3</sub>OH). The high  $R_f$  material (0.3–0.85, silica gel, hexanes) and low  $R_f$  material ( $R_f < 0.3$ , silica gel, hexanes) were separately chromatographed (Analtech, Silica Gel GF, 2000 micron) using 5% EtOAc/hexanes. All products isolated were identified by comparison of their spectroscopic properties (NMR, IR, Mass Spec.) with those previously reported. The yields were 2-(cyclohexylmethyl)naphthalene (50.1 mg, 41%),<sup>11a</sup> 1,2-di-(2-naphthyl)ethane (8.6 mg, 11%),<sup>15</sup> azine (4.5 mg, 5%) and 2-naphthaldehyde (9.4 mg, 11%).

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