Reactions of Lithiated Alkynes and Allenes with Isothiocyanates: A Simple and Efficient Synthesis of New Aryl- or Hetaryl-Substituted 3*H*-Azepines and 4,5-Dihydro-3*H*-azepines

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Abstract: A novel synthetic approach to the preparation of a wide range of 3*H*-azepines and 4,5-dihydro-3*H*-azepines bearing various aryl, hetaryl, alkyl, and heteroalkyl substituents from readily accessible starting materials (aryl- and hetaryl-substituted alkynes or allenes, *sec*-alkyl isothiocyanates, and alkyl halides) has been developed. The methodology is based on a fast and smooth conversion of conjugated 2-aza-1,3,5-trienes derived from 1-aza-1,3,4-trienes, S-alkylated adducts of isopropyl isothiocyanate and allenic or acetylenic carbanions, into seven-membered azaheterocycles, 3*H*-azepines and 4,5-dihydro-3*H*-azepines, using potassium *tert*-butoxide (THF–DMSO, ca. –30 °C, 30 min). The ratio of the heterocycles depends on the nature of the substituent on the allene or alkyne and on the 2-aza-1,3,5-triene derived therefrom.

Key words: 3*H*-azepines, 4,5-dihydro-3*H*-azepines, azatrienes, allenes, alkynes, isothiocyanate, metalation, electrocyclization

Seven-membered azaheterocycles, azepines and their derivatives, represent an important class of heterocyclic compounds[1] and they are the focus of numerous synthetic, theoretical, and medical investigations, primarily due to their peculiar structure, high reactivity (notably in pericyclic reactions), and wide variety of bioactivity.[2] In theoretical studies of azepines, considerable interest has been directed towards various stereochemical and thermodynamic aspects, including tautomerism,[3] valence isomerism,[4] sigmatropic rearrangements,[3b,5] the transannular effect of the nitrogen lone pair,[2a] aromaticity/anti-aromaticity,[2b,c,6] and intramolecular hydrogen bonds.[7] Azepine derivatives, especially partially or fully reduced azepines,[1d–i] benzazepines,[8] and diazepines[9] are widely used in pharmacology and medicine, first of all, as psychotropic, antidepressant, and anticonvulsant drugs [Carbamazepine (synonyms: Amizepin, Carbagretil, Carbazep, Finlepsin, Mazetol, Neurotol, Simonil, Stazepin, Tegretal, Tegretol, Temporal, Zeptol, etc.),[10] Insidon (synonyms: Dinsidon, Opipramol, Opramol, Oprimol, etc.),[11] Imipramine and its derivatives and analogues (Clomipramine, Desimipramine, Melipramin, etc.)[12]] for the treatment of trigeminal neuralgia, diverse forms of epilepsy, schizophrenia, and other mental disorders (memory impairment, alcoholism, senile dementia, Alzheimer's disease).[1,10–13] Many natural azepines, including azepine alkaloids and their synthetic congeners, are used or regarded as a potential anticancer, antibacterial, anti-HIV, and other types of drugs.[14]

Therefore, the search for and the development of novel and efficient synthetic approaches to seven-membered azaheterocycles providing access to new representatives is of high interest to both heterocyclic chemistry and medicine.

In the past few years it has been well documented that azatrienic systems, readily available by simple and efficient one-pot synthesis from isothiocyanates and acetylenic or dienic carbanions,[15] can be utilized in heterocyclic synthesis as unique common precursors of abundance fundamental four-, five-, and six-membered aza- and thiaheterocycles (pyrroles, cyclobuta[1,2-*b*]pyrroles, pyridines, dihydropyridines, dihydropyridinones, pyridinethiones, quinolines, thietanes, thiophenes, dihydrothiopyrans, etc.), including bi- and polycyclic architectures.[15,16]

Recently, we found that conjugated 2-aza-1,3,5-trienes **2**, products of a sigmatropic [1,5]-H shift in the corresponding 1-aza-1,3,4-trienes **1**, derived from readily accessible allenic ether or allenic acetals and isopropyl isothiocyanate, by treatment with potassium *tert*-butoxide in tetrahydrofuran or dimethyl sulfoxide–tetrahydrofuran undergoes an unprecedented transformation to 6-alkoxy-2-methyl-3*H*-azepines **3** and 3-alkoxy-7-methyl-2-(methylsulfanyl)-4,5-dihydro-3*H*-azepines **4**, the product ratio being markedly dependent on the alkoxy substituent and reaction conditions (Scheme 1).[17]

In particular, treatment of methoxy-substituted 2-aza-1,3,5-triene **2a** with potassium *tert*-butoxide in dimethyl sulfoxide–tetrahydrofuran at ca. –30 °C for 30 minutes (Method A) gave the corresponding 3*H*-azepine **3a** and 4,5-dihydro-3*H*-azepine **4a** in a ratio of ~1:1 (Table 1, entry 1).[17a] However, acetal analogues **2b**,**c**, in contrast to **2a**, react with potassium *tert*-butoxide under similar conditions yielding mainly 4,5-dihydro-3*H*-azepines **4b**,**c** (88–92% along with 3*H*-azepines **3b**,**c**) (entries 3–5).[17b] 3*H*-Azepine **3a** and 4,5-dihydro-3*H*-azepine **4a** were obtained from 2-aza-1,3,5-triene **2a** in a ratio of ~1:3 when the reaction was carried out in tetrahydrofuran (in the ab-

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Ol'ga A. Tarasova received her diploma from Irkutsk Polytechnic Institute (Russia) in 1971 and her Ph.D. in Chemistry from the Irkutsk Institute of Organic Chemistry in 1975. She is now a Senior Staff Scientist at the A. E. Favorsky Irkutsk Institute of Chemistry. Her research interests are the chemistry of acetylene and allene systems in superbasic medium. She is the author of over 130 papers and 23 author's certificates and patents.

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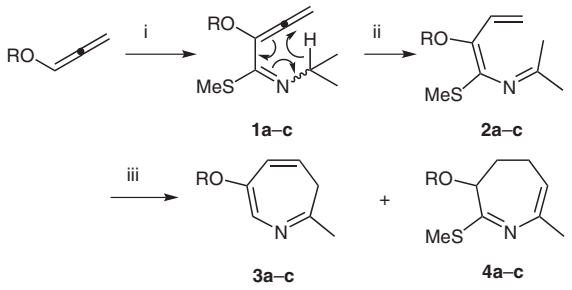
Boris A. Trofimov was born in Tchita, Russia in 1938. He received his diploma in 1961, his Ph.D. in 1964, and his D.Sc. in 1970. He became a Professor in 1974 and in 1990 a Corresponding Member of the Academy of Sciences (USSR). He became a Full Member (Academician) of the Russian Academy of Sciences in 2000. He is currently Director of the A. E. Favorsky Irkutsk Institute of Chemistry, Head of the Laboratory of Unsaturated Heteroatomic Compounds. Boris Trofimov is a member of the editorial board of the Russian Journal of Organic Chemistry, Russian Journal of Heterocyclic Compounds, and Journal of Sulfur Chemistry. He was awarded the Butlerov Prize of the Russian Academy of Science in 1997 and the Medal and Diploma of a Mendeleev Reader (St. Petersburg) in 2003. In 2011 he was elected Professor Emeritus of the Chemical Faculty of Saint-Petersburg State University. He is the author and co-author of over 2000 papers, 60 reviews, and 21 monographs. His current scientific interests are focused on: organic synthesis based on acetylene and its derivatives; heterocyclic chemistry, particularly, the chemistry of pyrroles, indoles, imidazoles, pyridines, and furans; organic chemistry of phosphorus (halogen-free synthesis), sulfur, selenium, tellurium; addition reactions to multiple bonds; and superbase catalysts and reagents.



Scheme 1 *Reagents and conditions:* (i) 1. *n*-BuLi (1 equiv), THF–hexane; 2. *i*-PrNCS; 3. MeI; (ii) [1,5]-H shift: 65–67 °C, 10–15 min (for **1a**) or r.t., 4 h (for **1b**,**c**); (iii) *t*-BuOK (1.0–1.2 equiv), THF–DMSO (4.3–5:1), ca. –30 °C, 30 min (Method A) or THF, 0 °C, 10 min (Method B).

Table 1 Transformation of 2-Aza-1,3,5-trienes **2** into 3*H*-Azepines **3** and 4,5-Dihydro-3*H*-azepines **4** (Scheme 1)

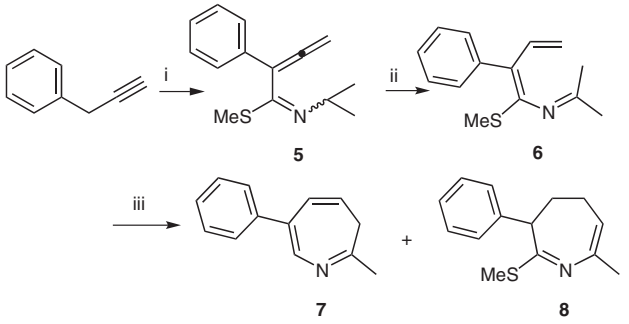
Entry	Substrate	R	Method[a]	Yield (%)	Ratio **3**/**4**[b]
1	**2a**	Me	A	71	~1:1
2	**2a**	Me	B	71	~1:3
3	**2b**	CH(Me)OEt	A	89	~1:12.5
4	**2b**	CH(Me)OEt	B	82	~1:12.5
5	**2c**	CH(Me)OBu	A	89	~1:11.5

[a] For Methods A and B see Scheme 1.
[b] In the crude product (by ^{1}H NMR).

sence of DMSO) at 0 °C for 10 minutes (Method B, entry 2).[17a]

The whole process, from lithiation of the allene with butyllithium to formation of the azepine nucleus, was accomplished in three preparative steps: (1) one-pot synthesis of 1-aza-1,3,4-triene **1** (by nucleophilic addition of allenic carbanion, generated in situ from the corresponding allene, to isothiocyanate, followed by S-methylation of the adduct with MeI); (2) thermally induced isomerization of azatriene **1** into 2-aza-1,3,5-triene **2** (through a sigmatropic [1,5]-H shift); (3) rapid transformation of 2-aza-1,3,5-triene **2** into 3*H*-azepine **3** and 4,5-dihydro-3*H*-azepine **4** under the action of potassium *tert*-butoxide (via deprotonation of azatriene **2** and spontaneous [1,7]-electrocyclization of the emerging carbanion).

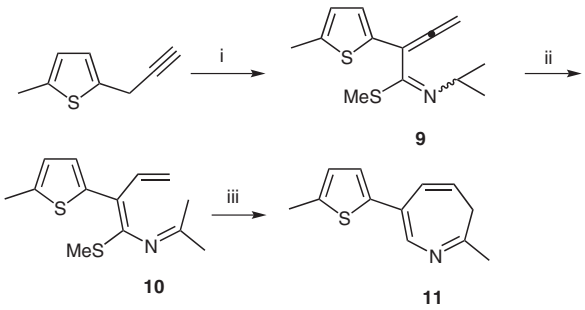
We have also found that this procedure can be successfully applied to aryl- or hetaryl-substituted azatrienic systems to give azepines and dihydroazepines containing an aryl or hetaryl substituent. Thus, phenyl-substituted 2-aza-1,3,5-triene **6**, prepared from dilithiated 1-(2-propynyl)benzene and isopropyl isothiocyanate via one-pot synthesis and isomerization of 1-aza-1,3,4-triene **5**, under the action of an equimolar amount of potassium *tert*-butoxide in tetrahydrofuran at 15 °C for 30 minutes (Method C) was easily converted into the previously unknown 2-methyl-6-phenyl-3*H*-azepine (**7**) and 7-methyl-2-(methylsulfanyl)-3-phenyl-4,5-dihydro-3*H*-azepine (**8**) (ratio ~1:1 by ^{1}H NMR) (Scheme 2).[18] Total yield of products **7**



Scheme 2 *Reagents and conditions*: (i) 1. *n*-BuLi (2 equiv), THF–hexane; 2. *i*-PrNCS; 3. *t*-BuOH; 4. MeI; (ii) [1,5]-H shift (see Table 2); (iii) *t*-BuOK (1 equiv), THF, 15 °C, 30 min (Method C).

and **8** was 74% (after flash chromatography on silica gel, PE–Et_2O, 3:1).

Unlike phenyl-substituted 2-aza-1,3,5-triene **6** (Scheme 2),[18] when thienyl-substituted 2-aza-1,3,5-triene **10**, derived from dilithiated 5-methyl-2-(2-propynyl)thiophene, isopropyl isothiocyanate, and methyl iodide (via 1-aza-1,3,4-triene **9**), was treated with potassium *tert*-butoxide (by Method A), only the previously unknown 2-methyl-6-(5-methyl-2-thienyl)-3*H*-azepine (**11**) was isolated in 45% yield (Scheme 3).[19] The corresponding 4,5-dihydro-3*H*-azepine was not detected in this case even in the crude product (^{1}H NMR).



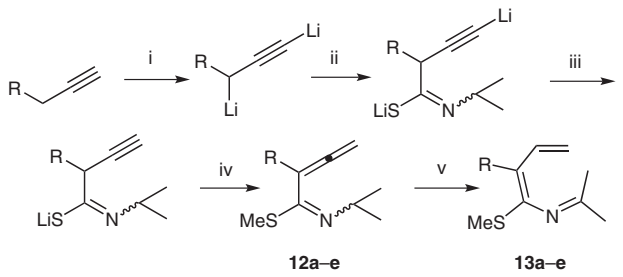
Scheme 3 *Reagents and conditions*: (i) 1. *n*-BuLi (2 equiv), THF–hexane; 2. *i*-PrNCS; 3. *t*-BuOH; 4. MeI; (ii) [1,5]-H shift (see Table 2); (iii) *t*-BuOK (1.2 equiv), THF–DMSO (4.5:1), ca. –30 °C, 30 min (45%).

Apparently, the application in these reactions of others alkynes or allenes, bearing aromatic and heteroaromatic substituents, provides an effective synthetic approach to new bicyclic azepine and dihydroazepine assemblies, promising scaffolds for the design of new medicinal agents and materials for various objectives, particularly having in mind that so far, general and efficient methods for their preparation are not known.

With the aim to obtain a new range of aryl- and hetaryl-substituted 3*H*-azepines and 4,5-dihydro-3*H*-azepines, as well as to investigate the scope and limitations this approach to their preparation, we synthesized a wide number of their precursors, earlier unknown and unavailable aryl- and hetaryl-substituted conjugated 2-aza-1,3,5-trienes **13**,

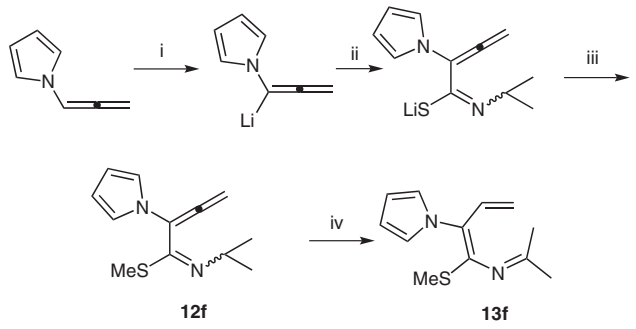
and studied their reactions upon treatment with potassium *tert*-butoxide.

1-Aza-1,3,4-trienes **12**, precursors of 2-aza-1,3,5-trienes **13**, were obtained in turn from dilithiated with butyllithium in tetrahydrofuran–hexane aryl- or hetaryl-substituted alkynes [1-(2-propynyl)benzenes and 1-methyl-2-(2-propynyl)-1*H*-pyrrole] (Scheme 4) or lithiated 1-(1,2-propadienyl)-1*H*-pyrrole (Scheme 5), isopropyl isothiocyanate, and methyl iodide in one preparative step (yields 63–95% by ^{1}H NMR).



Scheme 4 *Reagents and conditions*: (i) *n*-BuLi (2 equiv), THF–hexane, 10–15 °C, 20 min; (ii) *i*-PrNCS, ca. –30 °C, 20 min; (iii) *t*-BuOH; (iv) MeI; (v) [1,5]-H shift (see Table 2).

In the case of 1-(1,2-propadienyl)-1*H*-pyrrole, the first (i) or second (ii) stage was not completed under the investigated conditions and some unreacted starting compound was recovered (Scheme 5).



Scheme 5 *Reagents and conditions*: (i) *n*-BuLi (1 equiv), THF–hexane, –70 to –60 °C, 10 min; (ii) *i*-PrNCS, –35 to –30 °C, 20 min; (iii) MeI; (iv) [1,5]-H shift (see Table 2).

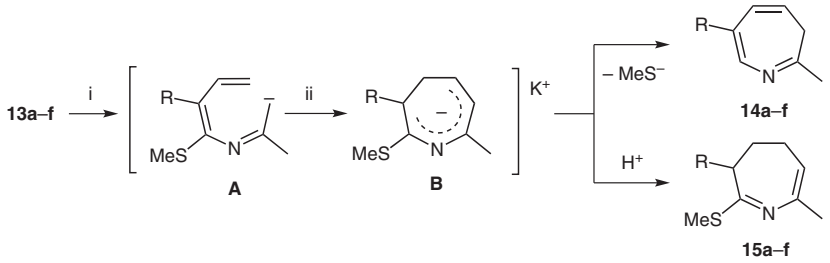
Then, compounds **12** were easily transformed into the corresponding 2-aza-1,3,5-trienes **13** via [1,5]-sigmatropic hydrogen shift. The conditions of thermal isomerization of 1-aza-1,3,4-trienes **12** and the values of their conversion are summarized in Table 2. For comparison, the data on isomerization of phenyl- **5** and thienyl-substituted 1-aza-1,3,4-trienes **9** into 2-aza-1,3,5-trienes **6** and **10**, respectively, are also included (entries 1 and 6). As seen from Table 2, the transformation of neat azatrienes **12** into **13** occurs at 55–84 °C for ~20 minutes (entries 2–5, 7, and 8), the conversion of 1-aza-1,3,4-trienes being ~100%, except for compounds **12a** (~88%) and **12c** (90%).

2-Aza-1,3,5-trienes **13a–f**, synthesized in this way, without further purification were smoothly converted into the earlier unknown aryl- or hetaryl-substituted 3*H*-azepines **14a–f** and 4,5-dihydro-3*H*-azepines **15a–f** upon treatment with potassium *tert*-butoxide (Scheme 6, Table 3). The reaction was performed in dry dimethyl sulfoxide–tetrahydrofuran (1:4.5–6.0) at ca. –30 °C with slight excess (1.1–1.5 equiv) of potassium *tert*-butoxide and was complete in 30 minutes. After aqueous workup, compounds **14** and **15** were obtained as a mixture in moderate to good yields. Deprotonation of phenyl-substituted 2-aza-1,3,5-triene **6** was also carried out under these conditions (Method A). The total yield of compounds **7** and **8** was comparable to this obtained by Method C (Scheme 2),[18] but their ratio changed from ~1:1 to ~2:1; a similar tendency to that observed for the transformations of methoxy-substituted 2-aza-1,3,5-triene **2a** into 3*H*-azepine **3a** and 4,5-dihydro-3*H*-azepine **4a** by Methods A and B (Scheme 1, Table 1, entries 1 and 2).[17a]

Similar to the synthesis of the above-mentioned 3*H*-azepines **3**, **7**, **11** and 4,5-dihydro-3*H*-azepines **4** and **8**,[17–19] the reaction is thought to proceed through the deprotonation of a methyl group from the azomethine moiety (N=CMe$_2$) of the 2-aza-1,3,5-trienic system **13** with potassium *tert*-butoxide, followed by isomerization of the initially formed carbanion **A** and spontaneous [1,7]-electrocyclization of isomerized anion resulting in the formation of azacycloheptadienyl anionic species **B** (Scheme 6). The unprecedented elimination of the sulfide anion from anionic intermediate **B** under the reaction con-

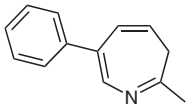
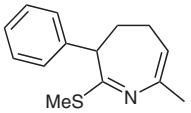
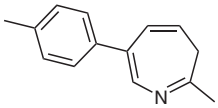
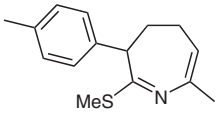
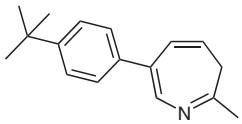
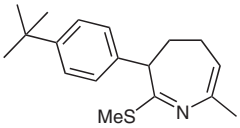
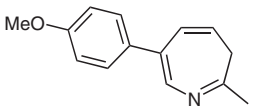
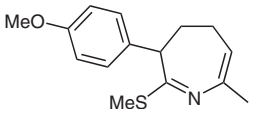
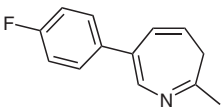
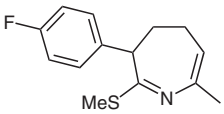
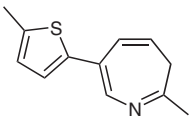
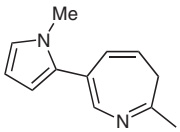
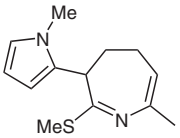
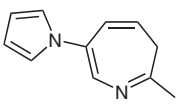
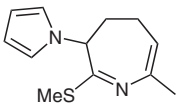
Table 2 Conditions for Isomerization of 1-Aza-1,3,4-trienes **5**, **9**, and **12** into 2-Aza-1,3,5-trienes **6**, **10**, and **13** (Schemes 2–5)

Entry	R	1-Aza-1,3,4-triene	Temp (°C)	Time (min)	2-Aza-1,3,5-triene	Conv. (%)
1	Ph	**5**[18]	80–85	30	**6**[18]	100
2	4-MeC$_6$H$_4$	**12a**	79–82	20	**13a**	88
3	4-*t*-BuC$_6$H$_4$	**12b**	80–84	20	**13b**	100
4	4-MeOC$_6$H$_4$	**12c**	80–82	20	**13c**	90
5	4-FC$_6$H$_4$	**12d**	79–82	20	**13d**	100
6	5-methyl-2-thienyl	**9**[19]	74–82	10	**10**[19]	100
7	1-methyl-1*H*-pyrrol-2-yl	**12e**	55–62	20	**13e**	100
8	1*H*-pyrrol-1-yl	**12f**	60–65	20	**13f**	100



Scheme 6 *Reagents and conditions*: (i) deprotonation with *t*-BuOK in THF–DMSO (Method A); (ii) isomerization and [1,7]-electrocyclization; yields: 14–74% for 3*H*-azepines **14a–f** and 8–56% for 4,5-dihydro-3*H*-azepines **15a–f**.

Table 3 Ratio and Total Yield of 3*H*-Azepines **7**, **11**, **14a–f** and 4,5-Dihydro-3*H*-azepines **8**, **15a–f**

Entry	3*H*-Azepine	4,5-Dihydro-3*H*-azepine	Ratio[a]	Total yield[b] (%)
1	 **7**[18]	 **8**[18]	70:30	66
2	 **14a**	 **15a**	90:10	56
3	 **14b**	 **15b**	75:25	99
4	 **14c**	 **15c**	75:25	72
5	 **14d**	 **15d**	55:45	65
6	 **11**[19]	–	100:0	56
7	 **14e**	 **15e**	22:78	76
8	 **14f**	 **15f**	13:87	52

[a] Ratio of azepine/dihydroazepine in crude product (by ^{1}H NMR).
[b] After rough separation of products by column chromatography on alumina.

ditions affords 3*H*-azepines **14**. The protonation of cyclic anion **B** upon aqueous workup gives (directly or after hydrogen shift) 4,5-dihydro-3*H*-azepines **15**.

Apart from our own previous work,[17–19] there is no methodology in the literature that allows the construction of both azepine and dihydroazepine rings from a common precursor, namely 2-aza-1,3,5-triene, under the same reaction conditions. Würthwein et al.[20] reported the synthesis of *N*-acyl-2,3-dihydro-1*H*-azepines and N-substituted 4,5-dihydro-1*H*-azepines from 1-phenyl-7-(4-tolyl)-2-azaheptatriene, 4-MePhCH=CHCH=CHCH=NCH$_2$Ph, and *N*-allyl-*N*-(3-phenyl- or 3-thienylprop-2-enylidene)amines, ArCH=CHCH=NCH$_2$CH=CH$_2$, respectively, via deprotonation with lithium diisopropylamide and subsequent trapping of anionic intermediates with various electrophiles. But in this case, deprotonation occurred on an azamethylene fragment activated by a phenyl or vinyl group to furnish the only N-substituted dihydro-1*H*-azepines. To the best of our knowledge, the use of potassium *tert*-butoxide for the metalation of aldimines and ketimines has also not been previously reported; the reagent generally used for this objective is lithium diisopropylamide.[21]

In the present study, we have found that, in analogy to methoxy- and acetal-substituted derivatives **2** (Scheme 1), the ratio of 3*H*-azepine/4,5-dihydro-3*H*-azepine is critically dependent on the nature of the substituent at the 2-position of starting 2-aza-1,3,5-triene (Table 3). But, in contrast to acetal-substituted 2-aza-1,3,5-trienes **2b**,**c** which under similar conditions (Method A) yield mainly 4,5-dihydro-3*H*-azepines **4b**,**c** (ratio of **4b**,**c**/**3b**,**c** 11.5–12.5:1) (Table 1, entries 3 and 5),[17b] aryl- and hetaryl-substituted 2-aza-1,3,5-trienes **6**, **10**, and **13** in the most of cases afforded 3*H*-azepines as the main product.

Thus, deprotonation of 4-methylphenyl- **13a**, 4-*tert*-butylphenyl- **13b**, and 4-methoxyphenyl-substituted 2-aza-1,3,5-trienes **13c** led to a mixtures of the corresponding 3*H*-azepines and 4,5-dihydro-3*H*-azepines in a ratio of 90:10 to 75:25 (Table 3, entries 2–4). 4-Fluorophenyl-substituted 2-aza-1,3,5-triene **13d** also gave a mixture of 3*H*-azepine **14d** and 4,5-dihydro-3*H*-azepine **15d** but with slight predominance of azepine (~55% in mixture) (entry 5). Thienyl-substituted azatriene **10**, as already mentioned, gave exclusively 3*H*-azepine **11** (entry 6). Meanwhile the replacement of the 5-methyl-2-thienyl substituent in the initial 2-aza-1,3,5-triene with another five-membered aromatic heterocycle, namely the 1-methyl-1*H*-pyrrol-2-yl substituent surprisingly led to preferential formation of 4,5-dihydro-3*H*-azepine **15e** (~78% in a mixture with 3*H*-azepine **14e**) (entry 7). The same effect gives the 1*H*-pyrrol-1-yl substituent in 2-aza-1,3,5-triene **13f** (entry 8). In this case, the content of 4,5-dihydro-3*H*-azepine **15f** in a mixture with azepine **14f** was ~87%.

The nature of such a strong and unpredictable (from the point of view of stereoelectronic effects) influence of the substituent [methoxy, 1-(alkoxy)ethoxy, phenyl, thienyl, pyrrolyl] in the starting 2-aza-1,3,5-triene and/or intermediary azacycloheptadienyl anionic species **B** (Scheme 6) on the ratio of azacycloheptadienes and -trienes is puzzling. Therefore, additional studies will be necessary to obtain a correct explanation for these results.

The 3*H*-azepines and 4,5-dihydro-3*H*-azepines synthesized were isolated and purified by rough separation on alumina, followed by treatment with diluted hydrochloric acid and final purification by column chromatography on alumina or by recrystallization (for solids).[22] Microanalyses of the compounds gave satisfactory results.

The structures of the products have been assigned using ^{1}H, ^{13}C, ^{13}C$_{jmod}$, homo-, and heteronuclear 2D (^{1}H–^{1}H COSY-45, ^{1}H–^{13}C HSQC, and HMBC, ^{1}H–^{15}N HMBC) NMR and IR spectroscopy and mass spectrometry.

In conclusion, the methodology developed represents a novel general synthetic protocol for the preparation of new aryl- and hetaryl-substituted 3*H*-azepines and 4,5-dihydro-3*H*-azepines from isothiocyanates and propynes or allenes which are otherwise not easily available by other approaches. The procedure involves three very simple preparative operations: one-pot synthesis of 1-aza-1,3,4-trienes (through S-alkylation of the adduct of isothiocyanate with allenic or acetylenic carbanion), their thermally induced isomerization into 2-aza-1,3,5-trienes, and rapid transformation of the latter into the corresponding 3*H*-azepines and 4,5-dihydro-3*H*-azepines in the presence of potassium *tert*-butoxide under mild reaction conditions. The novel representatives of the seven-membered azaheterocycles combining the properties of both azepines and fundamental substituents, such as benzenes, pyrroles, thiophenes, and sulfides, can be of considerable theoretical, synthetic, and practical interest, including their potential application as promising precursors for drug design.

1-(1,2-Propadienyl)-1*H*-pyrrole, 1-(2-propynyl)benzenes, 1-methyl-2-(2-propynyl)-1*H*-pyrrole, 5-methyl-2-(2-propynyl)thiophene, and *i*-PrNCS were prepared as described in the literature.[15a,23] *n*-BuLi (2.5 M soln in hexane), *t*-BuOK, and solvents are commercially available. All solvents were purified according to standard procedures. All reactions (with the exception of isomerization of 1-aza-1,3,4-trienes into 2-aza-1,3,5-trienes) were performed under anhydrous conditions and under an argon atmosphere. For all reactions at low temperatures a cooling bath with liquid N_2 was used. All reactions were monitored by TLC on precoated with Merck silica gel 60 F254 plates, were visualized by exposure to I_2 vapor. PE refers to light petroleum.

IR spectra were measured neat or as KBr pellets on a Bruker Vertex-70 infrared spectrophotometer. ^{1}H (400.13 MHz), ^{13}C (100.62 MHz), and ^{15}N (40.55 MHz) NMR spectra were recorded on Bruker DPX-400 and Bruker AV-400 spectrometers in $CDCl_3$ soln at r.t., referenced to HMDS (for ^{1}H and ^{13}C) and $MeNO_2$ (for ^{15}N) as internal standards. Assignments of spectra were carried out using 2D experiments. The mass spectra (EI, 70 eV) were recorded on a Shimadzu GCMS-QP5050A instrument. The microanalyses were performed on a Flash EA 1112 Series elemental analyzer. Melting points were determined using a Kofler micro hot stage.

Full spectral data for all novel compounds are given below, all previously characterized compounds gave spectra consistent with the literature.

1-Aza-1,3,4-trienes 5, 9, 12a–e; General Procedure

To a stirred soln of corresponding alkyne (50 mmol) in THF (115 mL) under argon, at –95 °C, *n*-BuLi (40 mL, 100 mmol) was added. After stirring for an additional 20 min at 10–15 °C, the soln was cooled to –90 °C and a mixture of *i*-PrNCS (5.05 g, 50 mmol) and THF (5 mL) was added in one portion. The temperature of the mixture was allowed to rise to ca. –30 °C, and maintained at this temperature for an additional 20–30 min. Then a mixture of *t*-BuOH (3.7 g, 50 mmol) and Et_2O (3 mL) was added at –55 °C. The temperature was allowed to rise to –40 °C, the mixture was cooled to –80 °C, and MeI (20 g, 141 mmol, excess) was then added in one portion, after which the temperature was allowed to rise to r.t. for ~1 h. The mixture was cooled to –80 °C, and then quenched with sat. aq NH_4Cl soln (100 mL) and extracted with Et_2O (3 × 30 mL). The combined organic extracts were washed with H_2O (3 × 15 mL), dried ($MgSO_4$), and concentrated under reduced pressure at a bath temperature of 20 °C to give a residue consisting of corresponding 1-aza-1,3,4-triene as a mixture of *syn*- and *anti*-isomers. 1-Aza-1,3,4-trienes **12a** and **12d** were obtained on a scale of 26 and 29 mmol, respectively. The crude products were purified by flash column chromatography on neutral alumina (PE). Yields and characteristic data of 1-aza-1,3,4-trienes **5**, **9**, **12a–e** are reported below.

Methyl *N*-Isopropyl-2-phenyl-2,3-butadienimidothioate (5)

Yellow solid; yield: 90% (^{1}H NMR), 8.16 g (71%); ratio major/minor (^{1}H NMR) ~70:30; mp 46–48 °C.

IR (KBr): 1937 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.22 [d, ^3J = 6.1 Hz, 6 H, NCH(CH_3)$_2$], 2.39 (s, 3 H, SMe), 3.97 [septet, ^3J = 6.1 Hz, 1 H, NCH(CH$_3$)$_2$], 4.93 (s, 2 H, CH$_2$=), 7.08 (m, 1 H, H-*p*), 7.20 (t, ^3J = 7.7 Hz, 2 H, H-*m*), 7.52 (d, 2 H, H-*o*); δ (minor isomer) = 1.40 [d, ^3J = 6.1 Hz, 6 H, NCH(CH_3)$_2$], 2.01 (s, 3 H, SMe), 4.26 [septet, ^3J = 6.1 Hz, 1 H, NCH(CH$_3$)$_2$], 4.95 (s, 2 H, CH$_2$=), 7.11 (m, 1 H, H-*p*), 7.30 (m, 2 H, H-*m*), 7.64 (m, 2 H, H-*o*).

Methyl *N*-Isopropyl-2-(4-methylphenyl)-2,3-butadienimidothioate (12a)

Light yellow mobile liquid; yield: 76% (^{1}H NMR), 2.16 g (34%); ratio major/minor (^{1}H NMR) ~70:30.

IR (neat): 1938 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.05 [d, ^3J = 6.5 Hz, 6 H, NCH(CH_3)$_2$], 2.29 (br s, 3 H, Ph-4-CH_3), 2.35 (s, 3 H, SMe), 3.75 [septet, ^3J = 6.5 Hz, 1 H, NCH(CH$_3$)$_2$], 5.22 (s, 2 H, CH$_2$=), 7.11, 7.19 (2 d, ^3J = 7.9 Hz, 4 H, H-*o*,*m*); δ (minor isomer) = 1.24 [d, ^3J = 6.0 Hz, 6 H, NCH(CH_3)$_2$], 2.29 (br s, 3 H, Ph-4-CH_3), 2.21 (s, 3 H, SMe), 3.83 [septet, ^3J = 6.0 Hz, 1 H, NCH(CH$_3$)$_2$], 5.30 (s, 2 H, CH$_2$=), 7.11, 7.28 (2 d, ^3J = 8.1 Hz, 4 H, H-*o*,*m*).

$^{13}C_{jmod}$ NMR: δ (major isomer) = 13.20 (SMe), 23.77 [NCH(*C*H$_3$)$_2$], 54.00 [N*C*H(CH$_3$)$_2$], 79.94 (CH$_2$=), 104.32 (C2), 125.73, 129.36 (4 C-*o*,*m*), 137.22 (C-*i*), 157.05 (C=N), 136.83 (C-*p*), 205.75 (=C=); δ (minor isomer) = 14.96 (SMe), 22.65 [NCH(*C*H$_3$)$_2$], 53.49 [N*C*H(CH$_3$)$_2$], 80.36 (CH$_2$=), 106.03 (C2), 125.94, 129.11 (4 C-*o*,*m*), 136.10 (C-*p*), 136.84 (C-*i*), 157.68 (C=N), 207.68 (=C=).

^{1}H–^{15}N HMBC: δ (major isomer) = –59.00; δ (minor isomer) = –40.04.

Methyl 2-(4-*tert*-Butylphenyl)-*N*-isopropyl-2,3-butadienimidothioate (12b)

Red mobile liquid; yield: 90% (^{1}H NMR), 11.36 g (79%); ratio major/minor (^{1}H NMR) ~70:30.

IR (neat): 1939 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.07 [d, ^3J = 6.2 Hz, 6 H, NCH(CH_3)$_2$], 1.29 [s, 9 H, C(CH_3)$_3$], 2.36 (s, 3 H, SMe), 3.77 [septet, ^3J = 6.2 Hz, 1 H, NCH(CH$_3$)$_2$], 5.23 (s, 2 H, CH$_2$=), 7.21, 7.33 (2 d, ^3J = 8.4 Hz, 4 H, H-*o*,*m*); δ (minor isomer) = 1.25 [d, ^3J = 6.2 Hz, 6 H, NCH(CH_3)$_2$], 1.28 [s, 9 H, C(CH_3)$_3$], 2.24 (s, 3 H, SMe), 3.95 [septet, ^3J = 6.2 Hz, 1 H, NCH(CH$_3$)$_2$], 5.31 (s, 2 H, CH$_2$=), 7.38, 7.46 (2 d, ^3J = 8.4 Hz, 4 H, H-*o*,*m*).

$^{13}C_{jmod}$ NMR: δ (major isomer) = 13.30 (SMe), 23.84 [NCH(*C*H$_3$)$_2$], 31.21 [C(*C*H$_3$)$_3$], 34.51 [*C*(CH$_3$)$_3$], 54.09 [N*C*H(CH$_3$)$_2$], 79.95 (CH$_2$=), 104.25 (C2), 125.54, 125.66 (4 C-*o*,*m*), 129.24 (C-*i*), 150.53 (C-*p*), 157.14 (C=N), 205.90 (=C=); δ (minor isomer) = 15.11 (SMe), 22.68 [NCH(*C*H$_3$)$_2$], 31.26 [C(*C*H$_3$)$_3$], 34.48 [*C*(CH$_3$)$_3$], 53.59 [N*C*H(CH$_3$)$_2$], 80.43 (CH$_2$=), 105.90 (C2), 125.54, 125.76 (4 C-*o*,*m*), 130.33 (C-*i*), 150.37 (C-*p*), 157.86 (C=N), 207.88 (=C=).

The ^{1}H–^{13}C HMBC 2D experiment provided additional support for the proposed structure.

Methyl *N*-Isopropyl-2-(4-methoxyphenyl)-2,3-butadienimidothioate (12c)

Yellow solid; yield: 95% (^{1}H NMR), 8.30 g (64%); ratio major/minor (^{1}H NMR) ~70:30; mp 38–40 °C.

IR (KBr): 1937 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.05 [d, ^3J = 6.0 Hz, 6 H, NCH(CH_3)$_2$], 2.35 (s, 3 H, SMe), 3.76 [septet, ^3J = 6.0 Hz, 1 H, NCH(CH$_3$)$_2$], 3.77 (s, 3 H, OMe), 5.23 (s, 2 H, CH$_2$=), 6.84, 7.21 (2 d, ^3J = 8.4 Hz, 4 H, H-*o*,*m*); δ (minor isomer) = 1.24 [d, ^3J = 6.4 Hz, 6 H, NCH(CH_3)$_2$], 2.23 (s, 3 H, SMe), 3.75 (s, 3 H, OMe), 3.94 [septet, ^3J = 6.4 Hz, 1 H, NCH(CH$_3$)$_2$], 5.30 (s, 2 H, CH$_2$=), 6.84, 7.30 (2 d, ^3J = 8.5 Hz, 4 H, H-*o*,*m*).

$^{13}C_{imod}$ NMR: δ (major isomer) = 13.27 (SMe), 23.87 [NCH(*C*H$_3$)$_2$], 55.23 (OMe), 54.06 [N*C*H(CH$_3$)$_2$], 80.10 (CH$_2$=), 104.02 (C2), 114.16, 127.10 (4 C-*o*,*m*), 124.46 (C-*i*), 158.98 (C-*p*), 159.03 (N=C), 205.52 (=C=); δ (minor isomer) = 15.02 (SMe), 22.69 [NCH(*C*H$_3$)$_2$], 53.52 [N*C*H(CH$_3$)$_2$], 55.18 (OMe), 80.51 (CH$_2$=), 105.68 (C2), 114.09, 127.30 (4 C-*o*,*m*), 125.52 (C-*i*), 158.00 (C-*p*), 157.28 (N=C), 207.47 (=C=).

Methyl 2-(4-Fluorophenyl)-*N*-isopropyl-2,3-butadienimidothioate (12d)

Dark mobile liquid; yield: 76% (^{1}H NMR), 2.55 g (35%); ratio major/minor (^{1}H NMR) ~70:30.

IR (neat): 1939 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.05 [d, ^3J = 6.2 Hz, 6 H, NCH(CH_3)$_2$], 2.36 (s, 3 H, SMe), 3.72 [septet, ^3J = 6.2 Hz, 1 H, NCH(CH$_3$)$_2$], 5.25 (s, 2 H, CH$_2$=), 6.99 (t, $^3J_{H\text{-}F} \approx {}^3J_{H\text{-}H}$ = 8.6 Hz, 2 H, H-*m*), 7.25 (dd, $^4J_{H\text{-}F}$ = 5.3 Hz, 2 H, H-*o*); δ (minor isomer) = 1.25 [d, ^3J = 6.2 Hz, 6 H, NCH(CH_3)$_2$], 2.23 (s, 3 H, SMe), 3.94 [septet, ^3J = 6.2 Hz, 1 H, NCH(CH$_3$)$_2$], 5.33 (s, 2 H, CH$_2$=), 6.99 (t, $^3J_{H\text{-}F} \approx {}^3J_{H\text{-}H}$ = 8.6 Hz, 2 H, H-*m*), 7.35 (dd, $^4J_{H\text{-}F}$ = 5.3 Hz, 2 H, H-*o*).

$^{13}C_{jmod}$ NMR: δ (major isomer) = 13.18 (SMe), 23.74 [NCH(*C*H$_3$)$_2$], 54.07 [N*C*H(CH$_3$)$_2$], 80.23 (CH$_2$=), 103.64 (C2), 115.62 (d, $^2J_{F\text{-}C}$ = 21.5 Hz, C-*m*), 127.53 (d, $^3J_{C\text{-}F}$ = 8.3 Hz, C-*o*), 128.42 (d, $^4J_{C\text{-}F}$ = 3.3 Hz, C-*i*), 156.65 (C=N), 162.11 (d, $^1J_{C\text{-}F}$ = 247.4, C-*p*), 205.82 (=C=); δ (minor isomer) = 14.97 (SMe), 22.63 [NCH(*C*H$_3$)$_2$], 53.59 [N*C*H(CH$_3$)$_2$], 80.75 (CH$_2$=), 105.33 (C2), 115.59 (d, $^2J_{F\text{-}C}$ = 22.0 Hz, C-*m*), 127.72 (d, $^3J_{C\text{-}F}$ = 8.1 Hz, C-*o*), 129.35 (d, $^4J_{C\text{-}F}$ = 2.8 Hz, C-*i*), 157.39 (C=N), 162.11 (d, $^1J_{C\text{-}F}$ = 247.4 Hz, C-*p*), 207.80 (=C=).

Methyl *N*-Isopropyl-2-(5-methyl-2-thienyl)-2,3-butadieneimidothioate (9)

Transparent brown mobile liquid; yield: 90% (^{1}H NMR), 7.41 g (59%); ratio major/minor (^{1}H NMR) ~60:40.

IR (neat): 1934 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.08 [d, ^3J = 6.2 Hz, 6 H, NCH(CH_3)$_2$], 2.35 (s, 3 H, SMe), 2.41 (s, 3 H, Me-5′), 3.86 [septet, ^3J = 6.2 Hz, 1 H, NCH(CH$_3$)$_2$], 5.21 (s, 2 H, CH$_2$=), 6.58, 6.62 (2 d, ^3J = 2.7 Hz, 2 H, H3′, H4′); δ (minor isomer) = 1.23 [d, ^3J = 6.2 Hz, 6 H, NCH(CH_3)$_2$], 2.33 (s, 3 H, SMe), 2.41 (s, 3 H, Me-5′), 3.92 [septet, ^3J = 6.2 Hz, 1 H, NCH(CH$_3$)$_2$], 5.31 (s, 2 H, CH$_2$=), 6.58, 6.78 (2 d, ^3J = 2.7 Hz, 2 H, H3′, H4′).

^{13}C NMR: δ = 13.29, 15.41 (SMe), 22.71 (Me-5′), 23.93 [NCH(*C*H$_3$)$_2$], 53.71, 54.16 [N*C*H(CH$_3$)$_2$], 80.23, 80.98 (CH$_2$=), 112.14 (C2), 124.87, 125.66 (C3′, C4′), 133.73 (C5′), 140.35 (C2′), 156.16, 156.71 (C=N), 204.11, 207.39 (=C=).

Methyl *N*-Isopropyl-2-(1-methyl-1*H*-pyrrol-2-yl)-2,3-butadienimidothioate (12e)

Red mobile liquid; yield: 90% (^{1}H NMR), 8.63 g (74%); ratio major/minor (^{1}H NMR) ~70:30.

IR (neat): 1934 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.07 [d, ^3J = 6.1 Hz, 6 H, NCH(CH_3)$_2$], 2.33 (s, 3 H, SMe), 3.63 (s, 3 H, NMe), 3.89 [septet, ^3J = 6.1 Hz, 1 H, NCH(CH$_3$)$_2$], 5.20 (s, 2 H, CH$_2$=), 6.01 (m, 1 H, H3′), 6.07 (dd, $^3J_{4,5}$ = 3.6 Hz, $^3J_{4,3}$ = 2.8 Hz, 1 H, H4′), 6.58 (m, 1 H, H5′); δ (minor isomer) = 1.22 [d, ^3J = 6.4 Hz, 6 H, NCH(CH_3)$_2$], 2.29 (s, 3 H, SMe), 3.64 (s, 3 H, NMe), 3.90 [septet, ^3J = 6.4 Hz, 1 H, NCH(CH$_3$)$_2$], 5.30 (s, 2 H, CH$_2$=), 6.02 (m, 1 H, H3′), 6.11 (m, 1 H, H4′), 6.54 (m, 1 H, H5′).

^{13}C$_{jmod}$ NMR: δ (major isomer) = 13.40 (SMe), 23.86 [NCH(*C*H$_3$)$_2$], 35.72 (NMe), 53.80 [N*C*H(CH$_3$)$_2$], 80.00 (CH$_2$=), 107.73 (C3′), 110.02 (C4′), 111.71 (C2), 124.91 (C5′), 172.41 (C=N), 122.96 (C2′), 205.98 (=C=); δ (minor isomer) = 13.62 (SMe), 22.57 [NCH(*C*H$_3$)$_2$], 35.86 (NMe), 53.49 [N*C*H(CH$_3$)$_2$], 80.68 (CH$_2$=), 107.76 (C3′), 110.14 (C4′), 133.22 (C5′).

Methyl *N*-Isopropyl-2-(1*H*-pyrrol-1-yl)-2,3-butadienimidothioate (12f)

To a stirred soln of 1-(1,2-propadienyl)-1*H*-pyrrole (5.26 g, 50 mmol) in THF (50 mL) under argon, at –90 °C, *n*-BuLi (50 mmol, 20 mL) was added. After stirring for an additional 10 min at ca. –70 to –60 °C, the soln was cooled to –90 °C and a mixture of *i*-PrNCS (5.05 g, 50 mmol) and THF (5 mL) was added in one portion. The temperature of the mixture was allowed to rise to –35 to –30 °C, and maintained at this temperature for an additional 20 min. The soln was cooled to –80 °C and MeI (14 g, 100 mmol, excess) was then added in one portion, after which the temperature was allowed to rise to r.t. for 30 min. The mixture was cooled to –80 °C, and then quenched with sat. aq NH_4Cl soln (100 mL) and extracted with Et_2O (3 × 30 mL). The combined organic extracts were washed with H_2O (3 × 15 mL), dried ($MgSO_4$), and concentrated under a reduced pressure at a bath temperature of 20 °C to give a residue (10.40 g of dark mobile liquid) consisting of 1-aza-1,3,4-triene **12f** (~63%) as a mixture of *syn*- and *anti*-isomers, 2-aza-1,3,5-triene **13f** (~4%) and unreacted 1-(1,2-propadienyl)-1*H*-pyrrole (~33%) (by ^{1}H NMR). The residue was purified by flash column chromatography (neutral alumina, PE) to give a mixture (7.82 g) of 1-aza-1,3,4-triene **12f** (~58%), 2-aza-1,3,5-triene **13f** (~15%), and starting allene (~27%).

1-Aza-1,3,4-triene 12f

Transparent brown mobile liquid; yield: 63% (by ^{1}H NMR), 5.71 g (52%) after flash chromatography; ratio major/minor (^{1}H NMR) ~50:50.

IR (neat): 1964 cm^{-1} (C=C=C).

^{1}H NMR: δ (major isomer) = 1.23 [d, ^3J = 6.1 Hz, 6 H, NCH(CH_3)$_2$], 2.34 (s, 3 H, SMe), 3.78 [septet, ^3J = 6.1 Hz, 1 H, NCH(CH$_3$)$_2$], 5.55 (s, 2 H, CH$_2$=), 6.71 (m, 2 H, H3′, H4′), 6.73 (m, 2 H, H2′, H5′); δ (minor isomer) = 1.05 [d, ^3J = 6.1 Hz, 6 H, NCH(CH_3)$_2$], 2.17 (s, 3 H, SMe), 3.91 [septet, ^3J = 6.1 Hz, 1 H, NCH(CH$_3$)$_2$], 5.63 (s, 2 H, CH$_2$=), 6.72 (m, 2 H, H3′, H4′), 6.74 (m, 2 H, H2′, H5′).

2-Aza-1,3,5-trienes 6, 10, 13a–f; General Procedure

The isomerization of 1-aza-1,3,4-trienes into 2-aza-1,3,5-trienes was effected by rotating a sample on a rotary evaporator at a bath temperature of 55–85 °C for 10–30 min. The bath temperatures, reaction times, and conversions of 1-aza-1,3,4-trienes are reported in Table 2; spectral data are reported below. 2-Aza-1,3,5-trienes were used without further purification.

(1*E*)-*N*-(1-Methylethylidene)-1-(methylsulfanyl)-2-phenyl-1,3-butadien-1-amine (6)

Dark mobile liquid.

IR (neat): 3079, 3055, 3025, 2966, 2924, 2866, 2164, 2146, 2099, 1971, 1944, 1876, 1653, 1602, 1596, 1553, 1491, 1440, 1367, 1301, 1244, 1171, 1107, 1072, 1031, 992, 965, 887, 863, 802, 766, 700, 644, 564 cm^{-1}.

^{1}H NMR: δ = 1.95, 1.97 [2 s, 6 H, N=C(CH$_3$)$_2$], 2.21 (s, 3 H, SMe), 4.46, 4.79 (2 dd, $^3J_{trans}$ = 17.4 Hz, $^3J_{cis}$ = 10.5 Hz, $^2J_{gem}$ = 1.8 Hz, 2 H, CH$_2$=), 6.41 (dd, $^3J_{trans}$ = 17.4 Hz, $^3J_{cis}$ = 10.5 Hz, 1 H, CH=), 7.20 (m, 2 H, H-*o*), 7.28 (m, 1 H, H-*p*), 7.34 (m, 2 H, H-*m*).

^{13}C NMR: δ = 13.68 (SMe), 21.13, 27.39 [N=C(*C*H$_3$)$_2$], 112.05 (CH$_2$=), 121.22 (C2), 126.83 (CH=), 127.98, 130.58 (4 C-*o*,*m*), 133.52 (C-*p*), 137.54 (C-*i*), 142.06 (C1), 172.28 (N=C).

(1*E*)-*N*-(1-Methylethylidene)-2-(4-methylphenyl)-1-(methylsulfanyl)-1,3-butadien-1-amine (13a)

Yellow mobile liquid.

IR (neat): 3087, 3046, 3022, 3007, 2966, 2924, 2868, 2732, 2611, 2444, 2890, 2146, 2096, 2023, 2003, 1938, 1902, 1794, 1728, 1655, 1634, 1599, 1512, 1435, 1423, 1367, 1339, 1301, 1269, 1244, 1212, 1189, 1171, 1151, 1107, 1080, 1038, 1022, 992, 966, 886, 867, 819, 803, 789, 770, 749, 734, 725, 687, 669, 639, 614, 564, 550, 531, 502, 479, 450 cm^{-1}.

^{1}H NMR: δ = 1.969, 1.976 [2 s, 6 H, N=C(CH$_3$)$_2$], 2.22 (s, 3 H, SMe), 2.35 (s, 3 H, Ph-CH_3-4), 4.48, 4.80 (2 d, $^3J_{trans}$ = 17.1 Hz, $^3J_{cis}$ = 10.6 Hz, 2 H, CH$_2$=), 6.40 (dd, $^3J_{trans}$ = 17.1 Hz, $^3J_{cis}$ = 10.6 Hz, 1 H, CH=), 7.09, 7.18 (2 m, 4 H, H-*o*,*m*).

^{13}C$_{jmod}$ NMR: δ = 13.86 (SMe), 21.25 (Ph-*C*H$_3$-4), 21.29, 27.56 [N=C(*C*H$_3$)$_2$], 112.20 (CH$_2$=), 121.27 (C2), 128.94, 130.53 (4 C-*o*,*m*), 133.75 (CH=), 134.62 (C1), 136.57 (C-*p*), 136.83 (C-*i*), 172.34 (N=C).

(1*E*)-2-(4-*tert*-Butylphenyl)-*N*-(1-methylethylidene)-1-(methylsulfanyl)-1,3-butadien-1-amine (13b)

Viscous red-brown liquid.

^{1}H NMR: δ = 1.32 [s, 9 H, C(CH_3)$_3$], 1.98, 1.99 [2 s, 6 H, N=C(CH$_3$)$_2$], 2.23 (s, 3 H, SMe), 4.50, 4.80 (2 dd, $^3J_{trans}$ = 17.1 Hz, $^3J_{cis}$ = 10.6 Hz, $^2J_{gem}$ = 1.8 Hz, 2 H, CH$_2$=), 6.40 (dd, $^3J_{trans}$ = 17.1 Hz, $^3J_{cis}$ = 10.6 Hz, 1 H, CH=), 7.13, 7.38 (2 d, ^3J = 8.3 Hz, 4 H, H-*o*,*m*).

^{13}C$_{jmod}$ NMR: δ = 13.95 (SMe), 21.36, 27.63 [N=C(*C*H$_3$)$_2$], 31.38 [C(*C*H$_3$)$_3$], 34.50 [*C*(CH$_3$)$_3$], 112.25 (CH$_2$=), 121.20 (C2), 125.07, 130.26 (4 C-*o*,*m*), 133.81 (CH=), 134.51 (C-*i*), 141.92 (C1), 149.73 (C-*p*), 172.36 (N=C).

The ^{1}H–^{13}C HMBC 2D experiment provided additional support for the structure **13b**.

(1*E*)-2-(4-Methoxyphenyl)-*N*-(1-methylethylidene)-1-(methylsulfanyl)-1,3-butadien-1-amine (13c)

Dark mobile liquid.

IR (neat): 3087, 3033, 2997, 2963, 2925, 2868, 2835, 2612, 2528, 2477, 2279, 2146, 2095, 2030, 1939, 1886, 1774, 1728, 1655, 1608, 1603, 1575, 1553, 1508, 1464, 1439, 1367, 1338, 1302, 1284, 1244, 1173, 1132, 1105, 1080, 1035, 992, 966, 936, 886, 831, 806, 789, 761, 742, 673, 636, 615, 565, 509 cm^{-1}.

^1H NMR: δ = 1.98 [s, 6 H, N=C(CH_3)$_2$], 2.23 (s, 3 H, SMe), 3.80 (s, 3 H, OMe), 4.49, 4.80 (2 dd, $^3J_{trans}$ = 17.2 Hz, $^3J_{cis}$ = 10.6 Hz, $^2J_{gem}$ = 1.5 Hz, 2 H, CH_2=), 6.40 (dd, $^3J_{trans}$ = 17.2 Hz, $^3J_{cis}$ = 10.6 Hz, 1 H, CH=), 6.91, 7.13 (2 d, ^3J = 8.6 Hz, 4 H, H-*o*,*m*).

$^{13}C_{jmod}$ NMR: δ = 13.86 (SMe), 21.29, 27.55 [N=C(CH_3)$_2$], 55.02 (OMe), 112.06 (CH_2=), 113.61, 131.80 (4 C-*o*,*m*), 120.87 (C2), 129.83 (C-*i*), 133.93 (CH=), 142.22 (C1), 158.54 (C-*p*), 172.29 (N=C).

(1*E*)-2-(4-Fluorophenyl)-*N*-(1-methylethylidene)-1-(methylsulfanyl)-1,3-butadien-1-amine (13d)
Yellowish-orange liquid.

IR (neat): 3088, 3042, 2990, 2965, 2926, 2869, 2721, 2612, 2449, 2098, 2028, 1970, 1941, 1891, 1770, 1727, 1687, 1656, 1634, 1599, 1553, 1506, 1465, 1435, 1367, 1303, 1272, 1241, 1220, 1194, 1172, 1156, 1105, 1091, 1037, 1016, 992, 967, 937, 888, 870, 836, 815, 797, 762, 740, 727, 672, 644, 634, 612, 582, 562, 532, 505, 470, 388 cm^{-1}.

^1H NMR: δ = 1.983, 1.986 [2 s, 6 H, N=C(CH_3)$_2$], 2.23 (s, 3 H, SMe), 4.42, 4.80 (2 dd, $^3J_{trans}$ = 17.3 Hz, $^3J_{cis}$ = 10.6 Hz, $^2J_{gem}$ = 1.6 Hz, 2 H, CH_2=), 6.40 (dd, $^3J_{trans}$ = 17.3 Hz, $^3J_{cis}$ = 10.6 Hz, 1 H, CH=), 7.05 (t, $^3J_{H,H}$ = 8.8 Hz, 2 H, H-*m*), 7.17 (dd, $^3J_{H,F}$ = 5.6 Hz, 2 H, H-*o*).

$^{13}C_{jmod}$ NMR: δ = 13.80 (SMe), 21.32, 27.57 [N=C(CH_3)$_2$], 112.16 (CH_2=), 115.22 (d, $^3J_{C\text{-}F}$ = 21.3 Hz, C-*m*), 120.15 (C2), 132.43 (d, $^3J_{C\text{-}F}$ = 8.1 Hz, C-*o*), 133.48 (d, $^4J_{C\text{-}F}$ = 3.3 Hz, C-*i*), 133.70 (CH=), 142.65 (C1), 161.91 (d, $^1J_{C\text{-}F}$ = 246.0 Hz, C-*p*), 172.58 (N=C).

(1*E*)-*N*-(1-Methylethylidene)-1-(methylsulfanyl)-2-(5-methyl-2-thienyl)-1,3-butadien-1-amine (10)
Dark mobile liquid.

IR (neat): 3086, 3059, 2966, 2923, 2864, 1656, 1602, 1533, 1481, 1464, 1434, 1367, 1338, 1317, 1273, 1244, 1212, 1159, 1135, 1078, 1035, 989, 967, 939, 889, 844, 796, 662, 616 cm^{-1}.

^1H NMR: δ = 1.94, 2.01 [2 s, 6 H, N=C(CH_3)$_2$], 2.22 (s, 3 H, SMe), 2.48 (s, 3 H, Me-5′), 4.77, 4.84 (2 dd, $^3J_{trans}$ = 17.0 Hz, $^3J_{cis}$ = 10.6 Hz, $^2J_{gem}$ = 1.4 Hz, 2 H, CH_2=), 6.36 (dd, $^3J_{trans}$ = 17.0 Hz, $^3J_{cis}$ = 10.6 Hz, 1 H, CH=), 6.68 (s, 2 H, H3′, H4′).

^{13}C NMR: δ = 13.94 (SMe), 15.44 (Me-5′), 21.60, 27.57 [N=C(CH_3)$_2$], 112.13 (CH_2=), 113.41 (C2), 124.82, 133.74 (C3′, C4′), 128.66 (CH=), 135.81 (C1), 140.24 (C2′), 145.61 (C5′), 172.47 (N=C).

(1*E*)-*N*-(1-Methylethylidene)-2-(1-methyl-1*H*-pyrrol-2-yl)-1-(methylsulfanyl)-1,3-butadien-1-amine (13e)
Brown mobile liquid.

IR (neat): 3098, 3039, 2966, 2925, 2867, 2811, 2708, 2614, 2456, 2147, 2099, 1941, 1656, 1599, 1569, 1523, 1482, 1469, 1430, 1409, 1368, 1314, 1259, 1246, 1215, 1168, 1132, 1106, 990, 965, 891, 852, 799, 780, 710, 651, 610, 557, 526, 505, 473, 439, 380 cm^{-1}.

^1H NMR: δ = 1.98, 1.99 [2 s, 6 H, N=C(CH_3)$_2$], 2.24 (s, 3 H, SMe), 3.43 (s, 3 H, NMe), 4.48, 4.80 (2 dd, $^3J_{trans}$ = 16.8 Hz, $^3J_{cis}$ = 10.3 Hz, $^2J_{gem}$ = 1.6 Hz, 2 H, CH_2=), 6.02 (dd, $^3J_{3,4}$ = 3.2 Hz, $^4J_{3,5}$ = 1.5 Hz, 1 H, H3′), 6.15 (dd, $^3J_{4,5}$ = 2.8 Hz, 1 H, H4′), 6.35 (dd, $^3J_{trans}$ = 16.8 Hz, $^3J_{cis}$ = 10.3 Hz, 1 H, CH=), 6.67 (br t, 1 H, H5′).

^{13}C NMR: δ = 13.66 (SMe), 21.63, 27.66 [N=C(CH_3)$_2$], 33.86 (NMe), 107.02 (C3′), 109.94 (CH_2=), 111.74 (C4′), 121.59 (C5′), 122.24 (C2), 128.25 (C2′), 133.25 (CH=), 147.14 (C1), 172.44 (N=C).

(1*E*)-*N*-(1-Methylethylidene)-1-(methylsulfanyl)-2-(1*H*-pyrrol-1-yl)-1,3-butadien-1-amine (13f)
Brown viscous liquid.

IR (neat): 3099, 2968, 2926, 2868, 2630, 2454, 2147, 2098, 1965, 1656, 1606, 1577, 1522, 1493, 1484, 1432, 1369, 1332, 1281, 1247, 1202, 1171, 1136, 1103, 1078, 1066, 1048, 985, 967, 946, 890, 848, 825, 797, 756, 725, 674, 634, 611, 571 cm^{-1}.

^1H NMR: δ = 1.98, 1.99 [2 s, 6 H, N=C(CH_3)$_2$], 2.23 (s, 3 H, SMe), 4.44, 4.80 (2 dd, $^3J_{trans}$ = 16.9 Hz, $^3J_{cis}$ = 10.8 Hz, $^2J_{gem}$ = 1.0 Hz, 2 H, CH_2=), 6.23 (m, ^3J = 2.3 Hz, 2 H, H3′, H4′), 6.26 (dd, $^3J_{trans}$ = 16.9 Hz, $^3J_{cis}$ = 10.8 Hz, 1 H, CH=), 6.59 (t, ^3J = 2.3 Hz, 2 H, H2′, H5′).

^{13}C NMR: δ = 13.19 (SMe), 21.57, 27.86 [N=C(CH_3)$_2$], 108.02 (C3′, C4′), 110.37 (CH_2=), 120.06 (C2), 122.22 (C2′, C5′), 130.27 (CH=), 144.11 (C1), 173.80 (N=C).

3*H*-Azepines 7, 11, 14a–f and 4,5-Dihydro-3*H*-azepines 8, 15a–f; General Procedure for Method A
To a stirred soln of the 2-aza-1,3,5-triene (27.4–31.5 mmol) (in the case of **13a** and **13d**, 6.4 and 6.3 mmol, respectively) in THF (35–55 mL), THF–DMSO (1:1, 20–30 mL) and *t*-BuOK (1.1–1.5 equiv) were sequentially added at –65 °C. The mixture was warmed to –30 °C, stirred at this temperature for 30 min, then cooled to –60 °C, quenched with H_2O (~50 mL), and extracted with Et_2O (3 × 30 mL). The combined organic extracts were washed with H_2O (3 × 15 mL), dried ($MgSO_4$), and concentrated under a reduced pressure at a bath temperature of 20 °C. The products were purified and separated in the following way. Initially, column chromatography (neutral alumina, PE and PE–Et_2O, 10:1, 3:1) gave 2 fractions consisting mostly of azepine and dihydroazepine. Then, the fraction containing predominantly azepine was repetitively purified by column chromatography or recrystallized (PE). The fraction enriched in dihydroazepine (the ethereal soln) was vigorously shaken for few seconds with a calculated amount of ~3% HCl soln; the dihydroazepine remained in ethereal soln and the azepine, in the form of its iminium salt, passed into aqueous phase from which, after neutralization with a ~10% aq KOH soln, it was isolated by Et_2O. Both organic solns were dried ($MgSO_4$). Concentration under reduced pressure followed by column chromatography afforded pure dihydroazepine and an additional portion of azepine. The ratios and yields are reported in Table 3; physical and spectral data are reported below.

2-Methyl-6-phenyl-3*H*-azepine (7)
Scale: 31 mmol; THF–DMSO, 5.0:1; *t*-BuOK (1.2 equiv); dark brown oil; yield: 2.44 g (43%) after rough separation on alumina; 1.50 g (26%) after separation with HCl.

IR (neat): 3082, 3057, 3027, 2971, 2944, 2911, 2885, 2830, 1950, 1883, 1805, 1762, 1715, 1686, 1619, 1598, 1578, 1562, 1508, 1490, 1447, 1427, 1408, 1371, 1340, 1314, 1290, 1276, 1242, 1210, 1187, 1142, 1121, 1007, 1035, 1015, 1002, 957, 944, 894, 884, 817, 771, 750, 698, 647, 630, 616, 568, 510, 473, 415 cm^{-1}.

^1H NMR (50 °C*): δ = 2.18 (s, 3 H, Me-2), 2.54 (m, 2 H, CH_2-3), 5.43 (dtd, $^3J_{4,5}$ = 9.0 Hz, $^3J_{4,3}$ = 7.0 Hz, $^5J_{4,7}$ = 0.6 Hz, 1 H, H4), 6.43 (dd, $^3J_{5,4}$ = 9.0 Hz, $^4J_{5,7}$ = 1.8 Hz, 1 H, H5), 7.28 (m, 1 H, H-*p*), 7.36 (m, 2 H, H-*m*), 7.44 (m, 2 H, H-*o*), 7.64 (ddq, $^4J_{7,5}$ = 1.8 Hz, $^5J_{7,4}$ = 0.6 Hz, 1 H, H7); * CH_2-3 signal is not visible at r.t.

$^{13}C_{jmod}$ NMR: δ = 26.30 (Me-2), 38.42 (C3), 116.41 (C4), 127.08 (C5), 127.52 (2 C-*o*), 128.21 (C-*p*), 128.47 (2 C-*m*), 129.14 (C6), 138.14 (C7), 140.57 (C-*i*), 149.92 (C2).

The ^1H–^1H COSY-45, ^1H–^{13}C HSQC, and HMBC 2D experiments provided additional support for the structure **7**.

MS (EI): *m*/*z* (%) = 183 (100) $[M]^+$, 182 (74) $[M - 1]^+$, 168 (36), 141 (93), 115 (53).

The data are consistent with those previously reported.[18]

7-Methyl-2-(methylsulfanyl)-3-phenyl-4,5-dihydro-3*H*-azepine (8)

Colorless viscous liquid; yield: 1.61 g (23%) after rough separation on alumina; 1.30 g (18%) after separation with HCl; n_D^{21} 1.5866.

IR (neat): 3105, 3086, 3060, 3028, 2972, 2940, 2921, 1947, 1883, 1803, 1633, 1614, 1603, 1561, 1495, 1450, 1408, 1375, 1336, 1312, 1236, 1209, 1173, 1121, 1080, 1030, 1004, 972, 919, 896, 882, 840, 794, 784, 758, 739, 698, 651, 620, 611, 591, 549, 513, 468 cm^{-1}.

^1H NMR: δ = 1.93 (s, 3 H, Me-7), 1.92, 2.00 (2 m, 2 H, CH_2-4), 2.22 (s, 3 H, SMe), 2.28, 2.61 (2 m, 2 H, CH_2-5), 4.08 (dd, $^3J_{3,4}$ = 11.8 Hz, $^3J_{3,4'}$ = 6.7 Hz, 1 H, H3), 5.27 (br t, $^3J_{6,5}$ = 6.4 Hz, 1 H, H6), 7.26 (m, 5 H, H-*o*,*m*,*p*).

$^{13}C_{jmod}$ NMR: δ = 13.24 (SMe), 22.50 (Me-7), 23.48 (C4), 40.27 (C5), 50.77 (C3), 110.29 (C6), 127.30 (C-*p*), 128.00 (2 C-*o*), 129.41 (2 C-*m*), 138.60 (C7), 146.99 (C-*i*), 173.02 (C2).

The ^1H–^1H COSY-45, ^1H–^{13}C HSQC, and HMBC 2D experiments provided additional support for the structure **8**.

MS (EI): *m*/*z* (%) = 231 (16) $[M]^+$, 184 (100), 115 (50).

The data are consistent with those previously reported.[18]

2-Methyl-6-(4-methylphenyl)-3*H*-azepine (14a)

Scale: 6.4 mmol; THF–DMSO, 6.0:1; *t*-BuOK (1.4 equiv); yellow solid; yield: 0.60 g (48%) after rough separation on alumina; 0.50 g (40%) after recrystallization (PE); mp 67–68 °C.

IR (KBr): 3082, 3047, 3020, 2996, 2965, 2950, 2916, 2890, 2858, 1622, 1613, 1513, 1431, 1422, 1396, 1372, 1365, 1339, 1312, 1289, 1274, 1239, 1212, 1180, 1145, 1117, 1041, 1022, 1013, 1000, 965, 957, 946, 896, 886, 842, 822, 817, 760, 719, 670, 647, 631, 601, 563, 512, 460, 427, 413, 392 cm^{-1}.

^1H NMR: δ = 2.18 (s, 3 H, Me-4′), 2.35 (s, 3 H, Me-2), 2.55 (m, 2 H, CH_2-3), 5.42 (dt, $^2J_{4,5}$ = 9.0 Hz, $^3J_{4,3}$ = 6.9 Hz, 1 H, H4), 6.41 (dd, $^4J_{5,7}$ = 1.7 Hz, 1 H, H5), 7.17, 7.32 (2 d, ^3J = 7.8 Hz, 4 H, H-*o*,*m*), 7.62 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 20.94 (Me-4′), 26.17 (Me-2), 38.27 (C3), 116.15 (C4), 127.28, 129.06 (4 C-*o*,*m*), 128.17 (C5), 128.88 (C-*i*), 136.72 (C-*p*), 137.63 (C6), 137.69 (C7), 149.57 (C2).

MS (EI): *m*/*z* (%) = 197 (100) $[M]^+$, 198 (31) $[M + 1]^+$, 196 (90) $[M - 1]^+$, 182 (78), 181 (36), 155 (42), 141 (73), 115 (67).

7-Methyl-3-(4-methylphenyl)-2-(methylsulfanyl)-4,5-dihydro-3*H*-azepine (15a)

Yield: 0.12 g (8%) after rough separation on alumina.

^1H NMR: δ = 1.93 (s, 3 H, Me-7), 1.92, 2.00 (2 m, 2 H, CH_2-4), 2.19 (s, 3 H, Me-4′), 2.22 (s, 3 H, SMe), 2.28, 2.61 (2 m, 2 H, CH_2-5), 4.04 (dd, $^3J_{3,4}$ = 11.6 Hz, $^3J_{3,4'}$ = 6.6 Hz, 1 H, H3), 5.27 (br t, $^3J_{6,5}$ = 6.4 Hz, 1 H, H6), 7.17 (m, 2 H, H-*m*), 7.33 (m, 2 H, H-*o*).

6-(4-*tert*-Butylphenyl)-2-methyl-3*H*-azepine (14b)

Scale: 30.4 mmol; THF–DMSO, 4.6:1; *t*-BuOK (1.2 equiv); yellow solid; yield: 5.37 g (74%) after rough separation on alumina; 2.16 g (30%) after separation with HCl; mp 92–95 °C.

IR (KBr): 3030, 2960, 2894, 2865, 1619, 1561, 1511, 1473, 1458, 1425, 1414, 1392, 1363, 1337, 1287, 1275, 1266, 1210, 1187, 1116, 1109, 1023, 1012, 1000, 957, 945, 933, 896, 884, 843, 830, 821, 764, 745, 733, 659, 646, 586, 577, 543, 484, 417 cm^{-1}.

^1H NMR: δ = 1.32 [s, 9 H, $C(CH_3)_3$], 2.19 (s, 3 H, Me-2), 2.55 (m, 2 H, CH_2-3), 5.43 (dt, $^3J_{4,5}$ = 8.8 Hz, $^3J_{4,3}$ = 7.2 Hz, 1 H, H4), 6.43 (dd, $^4J_{5,7}$ = 1.2 Hz, 1 H, H5), 7.39 (m, 4 H, H-*o*,*m*), 7.65 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 26.30 (Me-2), 31.33 [C(CH_3)$_3$], 34.48 [C(CH_3)$_3$], 38.37 (C3), 116.35 (C4), 125.43, 127.15 (4 C-*o*,*m*), 128.24 (C5), 128.93 (C-*i*), 137.65 (C6), 137.87 (C7), 149.85 (C2), 150.12 (C-*p*).

The ^1H–^{13}C HSQC 2D experiment provided additional support for the structure **14b**.

MS (EI): *m*/*z* (%) = 239 (99) $[M]^+$, 240 (24) $[M + 1]^+$, 238 (53) $[M - 1]^+$, 224 (88), 182 (100), 115 (29), 77 (61).

3-(4-*tert*-Butylphenyl)-7-methyl-2-(methylsulfanyl)-4,5-dihydro-3*H*-azepine (15b)

Yield: 2.22 g (25%) after rough separation on alumina.

^1H NMR: δ = 1.28 [s, 9 H, $C(CH_3)_3$], 1.93 (s, 3 H, Me-7), 1.92, 2.00 (2 m, 2 H, CH_2-4), 2.23 (s, 3 H, SMe), 2.28, 2.61 (2 m, 2 H, CH_2-5), 4.05 (dd, $^3J_{3,4}$ = 11.8 Hz, $^3J_{3,4'}$ = 6.7 Hz, 1 H, H3), 5.28 (br t, $^3J_{6,5}$ = 6.4 Hz, 1 H, H6), 7.19 (m, $^3J_{Hm-Ho}$ = 8.1 Hz, 2 H, H-*o*), 7.26 (m, 2 H, H-*m*).

^{13}C NMR: δ = 13.32 (SMe), 22.53 (Me-7), 23.59 (C4), 31.30 [C(CH_3)$_3$], 34.44 [C(CH_3)$_3$], 40.54 (C5), 50.42 (C3), 110.35 (C6), 127.57 (C-*p*), 127.58 (2 C-*m*), 129.08 (2 C-*o*), 137.00 (C-*i*), 147.03 (C7), 173.02 (C2).

6-(4-Methoxyphenyl)-2-methyl-3*H*-azepine (14c)

Scale: 28.5 mmol; THF–DMSO, 4.8:1; *t*-BuOK (1.2 equiv); yellow solid; yield: 3.41 g (56%) after rough separation on alumina; 0.95 g (16%) after separation with HCl, followed by purification on alumina; mp 70–72 °C.

IR (KBr): 3096, 3069, 3026, 2997, 2981, 2960, 2933, 2907, 2892, 2834, 2033, 1971, 1912, 1848, 1780, 1764, 1724, 1676, 1656, 1619, 1607, 1572, 1512, 1499, 1450, 1439, 1423, 1399, 1367, 1341, 1313, 1283, 1246, 1215, 1179, 1147, 1114, 1035, 1015, 969, 958, 948, 898, 885, 834, 820, 790, 763, 727, 667, 648, 624, 605, 567, 531, 505, 449, 421, 405 cm^{-1}.

^1H NMR: δ = 2.18 (s, 3 H, Me-2), 2.56 (m, 2 H, CH_2-3), 3.81 (s, 3 H, OMe), 5.42 (dt, $^3J_{4,5}$ = 8.8 Hz, $^3J_{4,3}$ = 6.9 Hz, 1 H, H4), 5.39 (dd, $^4J_{5,7}$ = 1.6 Hz, 1 H, H5), 6.90, 7.36 (2 d, ^3J = 8.6 Hz, 4 H, H-*o*,*m*), 7.59 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 26.25 (Me-2), 38.32 (C3), 55.29 (OMe), 113.86 (2 C-*o*), 116.25 (C4), 128.29 (C5), 128.59 (2 C-*m*), 128.68 (C6), 133.20 (C-*i*), 137.45 (C7), 149.57 (C2), 158.97 (C-*p*).

MS (EI): *m*/*z* (%) = 213 (99) $[M]^+$, 214 (15) $[M + 1]^+$, 212 (58) $[M - 1]^+$, 128 (61).

3-(4-Methoxyphenyl)-7-methyl-2-(methylsulfanyl)-4,5-dihydro-3*H*-azepine (15c)

White solid; yield: 1.18 g (16%) after rough separation on alumina; 0.54 g (9%) after separation with HCl and purification on alumina; mp 55–56 °C.

IR (KBr): 3046, 3030, 2969, 2959, 2936, 2921, 2908, 2881, 2843, 2044, 1910, 1889, 1767, 1664, 1632, 1611, 1567, 1548, 1514, 1459, 1442, 1371, 1349, 1314, 1306, 1291, 1278, 1253, 1204, 1183, 1165, 1153, 1121, 1083, 1028, 1004, 936, 909, 882, 832, 815, 802, 788, 781, 666, 632, 591, 576, 551, 517, 503, 473, 455 cm^{-1}.

^1H NMR: δ = 1.93 (br s, 3 H, Me-7), 1.92, 2.00 (2 m, 2 H, CH_2-4), 2.22 (s, 3 H, SMe), 2.26, 2.58 (2 m, 2 H, CH_2-5), 3.77 (s, 3 H, OMe), 4.02 (dd, $^3J_{3,4}$ = 12.0 Hz, $^3J_{3,4'}$ = 6.7 Hz, 1 H, H3), 5.28 (br t, $^3J_{6,5}$ = 6.0 Hz, 1 H, H6), 6.84, 7.16 (2 d, ^3J = 8.8 Hz, 4 H, H-*o*,*m*).

$^{13}C_{jmod}$ NMR: δ = 13.35 (SMe), 22.52 (Me-7), 23.56 (C4), 40.89 (C5), 49.96 (C3), 55.16 (OMe), 110.33 (C6), 113.45 (2 C-*m*), 130.52 (2 C-*o*), 130.67 (C-*i*), 147.17 (C7), 158.93 (C-*p*), 173.84 (C2).

MS (EI): *m*/*z* (%) = 261 (65) $[M]^+$, 262 (9) $[M + 1]^+$, 260 (9) $[M - 1]^+$, 214 (37), 172 (65), 121 (50), 112 (100).

6-(4-Fluorophenyl)-2-methyl-3*H*-azepine (14d)
Scale: 6.3 mmol; THF–DMSO, 5.3:1; *t*-BuOK (1.2 equiv); yellow solid; yield: 0.52 g (41%) after rough separation on alumina; 0.31 g (24%) after recrystallization (PE); mp 66–67 °C.

IR (KBr): 3037, 3023, 3006, 2977, 2912, 2898, 1652, 1624, 1611, 1599, 1505, 1469, 1433, 1421, 1399, 1369, 1339, 1305, 1290, 1275, 1236, 1222, 1187, 1159, 1148, 1099, 1016, 971, 961, 952, 946, 897, 883, 836, 825, 806, 768, 722, 668, 648, 625, 601, 564, 523, 466, 443, 420, 404 cm^{-1}.

^1H NMR: δ = 2.18 (s, 3 H, Me-2), 2.54 (m, 2 H, CH_2-3), 5.42 (dt, $^3J_{4,5}$ = 8.8 Hz, $^3J_{4,3}$ = 7.2 Hz, 1 H, H4), 6.36 (dd, $^4J_{5,7}$ = 1.9 Hz, 1 H, H5), 7.03 (t, $^3J_{H,H} \approx {}^3J_{H,F}$ = 8.8 Hz, 2 H, H-*m*), 7.37 (dd, $^4J_{H,F}$ = 5.6 Hz, 2 H, H-*o*), 7.57 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 26.25 (Me-2), 38.41 (C3), 115.22 (d, $^3J_{C,F}$ = 21.5 Hz, 2 C-*m*), 116.51 (C4), 128.04 (C5), 128.13 (C-*i*), 129.04 (d, $^3J_{C,F}$ = 7.9 Hz, 2 C-*o*), 136.66 (C6), 138.04 (C7), 149.88 (C2), 162.29 (d, $^1J_{C,F}$ = 245.3 Hz, C-*p*).

The ^1H–^{13}C HSQC and HMBC 2D experiments provided additional support for the structure **14d**.

MS (EI): *m*/*z* (%) = 201 (97) $[M]^+$, 202 (32) $[M + 1]^+$, 200 (88) $[M - 1]^+$, 186 (44), 160 (59), 159 (100), 133 (88).

3-(4-Fluorophenyl)-7-methyl-2-(methylsulfanyl)-4,5-dihydro-3*H*-azepine (15d)
Yellow viscous liquid; yield: 0.37 g (24%) after rough separation on alumina followed by separation with HCl; 0.10 g (6%) after 2-fold purification on alumina.

IR (neat): 3033, 2964, 2924, 2873, 1712, 1634, 1605, 1567, 1510, 1465, 1445, 1437, 1416, 1377, 1361, 1349, 1312, 1235, 1226, 1192, 1175, 1159, 1151, 1122, 1099, 1082, 1035, 1015, 1004, 991, 973, 936, 910, 883, 830, 814, 791, 761, 724, 663, 635, 611, 590, 572, 548, 512, 479, 463, 429 cm^{-1}.

^1H NMR: δ = 1.40, 1.63, 1.98 (3 m, 2 H, CH_2-4), 1.93 (br s, 3 H, Me-7), 2.24 (s, 3 H, SMe), 2.28, 2.57 (2 m, 2 H, CH_2-5), 4.06 (dd, $^3J_{3,4}$ = 11.8 Hz, $^3J_{3,4'}$ = 6.5 Hz, 1 H, H3), 5.28 (br t, $^3J_{6,5}$ = 6.2 Hz, 1 H, H6), 6.99 (t, $^3J_{H,H} \approx {}^3J_{H,F}$ = 8.6 Hz, 2 H, H-*m*), 7.21 (dd, $^4J_{H,F}$ = 5.6 Hz, 2 H, H-*o*).

$^{13}C_{jmod}$ NMR: δ = 13.29 (SMe), 22.49 (Me-7), 23.46 (C4), 40.65 (C5), 50.04 (C3), 110.33 (C6), 114.92 (d, $^3J_{C,F}$ = 21.3 Hz, 2 C-*m*), 130.94 (d, $^4J_{C-F}$ = 7.9 Hz, 2 C-*o*), 134.40 (d, $^4J_{C,F}$ = 2.9 Hz, C-*i*), 162.13 (d, $^1J_{C,F}$ = 246.1 Hz, C-*p*), 147.10 (C7), 172.85 (C2).

MS (EI): *m*/*z* (%) = 249 (67) $[M]^+$, 250 (13) $[M + 1]^+$, 248 (7) $[M - 1]^+$, 202 (43), 201 (33), 200 (37), 161 (40), 160 (77), 159 (47), 133 (77), 112 (100).

2-Methyl-6-(5-methyl-2-thienyl)-3*H*-azepine (11)
Scale: 28 mmol; THF–DMSO, 4.5:1; *t*-BuOK (1.2 equiv); light-brown solid; yield: 3.18 g (56%) after rough separation on alumina; 2.59 g (45%); mp ~56 °C.

^1H NMR: δ = 2.15 (s, 3 H, Me-2), 2.39 (m, 2 H, CH_2-3), 2.44 (s, 3 H, Me-5′), 5.39 (dt, $^3J_{4,5}$ = 8.8 Hz, $^3J_{4,3}$ = 6.9 Hz, 1 H, H4), 6.45 (dd, $^3J_{5,4}$ = 8.8 Hz, $^4J_{5,7}$ = 1.7 Hz, 1 H, H5), 6.64 (dq, $^3J_{4',3'}$ = 3.6 Hz, $^4J_{4',Me}$ = 1.0 Hz, 1 H, H4′), 6.81 (d, $^3J_{3',4'}$ = 3.6 Hz, 1 H, H3′), 7.65 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 15.31 (Me-5′), 26.21 (Me-2), 38.35 (C3), 116.61 (C4), 123.14 (C6), 123.62 (C3′), 125.83 (C4′), 127.00 (C5), 136.69 (C7), 138.76 (C5′), 141.76 (C2′), 149.90 (C2).

The ^1H–^{13}C HMBC and HSQC 2D experiments provided additional support for the structure **11**.

MS (EI): *m*/*z* (%) = 203 (100) $[M]^+$, 202 (73), 188 (28), 161 (20), 128 (22), 101 (20).

The data are consistent with those previously reported.[19]

2-Methyl-6-(1-methyl-1*H*-pyrrol-2-yl)-3*H*-azepine (14e)
Scale: 31.5 mmol; THF–DMSO, 4.6:1; *t*-BuOK (1.5 equiv); orange liquid; yield: 1.2 g (20%) after rough separation on alumina; n_D^{21} 1.5966.

IR (neat): 3099, 3024, 2971, 2944, 2910, 2880, 2830, 2718, 1615, 1573, 1542, 1500, 1484, 1470, 1427, 1406, 1370, 1332, 1307, 1284, 1238, 1210, 1183, 1141, 1090, 1056, 1021, 1002, 996, 954, 942, 898, 888, 872, 817, 783, 760, 713, 650, 631, 609, 557, 504, 405 cm^{-1}.

^1H NMR: δ = 1.23, 2.55 (2 m, 2 H, CH_2-3), 2.17 (s, 3 H, Me-2), 3.52 (s, 3 H, NMe), 5.33 (dt, $^3J_{4,5}$ = 8.7 Hz, $^3J_{4,3}$ = 7.2 Hz, 1 H, H4), 6.12 (dd, $^3J_{4',3'}$ = 3.6 Hz, $^3J_{4',5'}$ = 2.9 Hz, 1 H, H4′), 6.21 (dd, $^3J_{3',4'}$ = 3.6 Hz, $^4J_{3',5'}$ = 1.8 Hz, 1 H, H3′), 6.32 (dd, $^4J_{5,7}$ = 1.3 Hz, 1 H, H5), 6.64 (t, $^4J_{5',3'}$ = 1.8 Hz, 1 H, H5′), 7.48 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 26.05 (Me-2), 34.48 (NMe), 38.00 (C3), 107.08 (C4′), 108.39 (C3′), 114.57 (C4), 120.63 (C6), 123.54 (C5′), 128.87 (C5), 133.75 (C2′), 139.71 (C7), 149.11 (C2).

The ^1H–^{13}C HSQC and HMBC 2D experiments provided additional support for the structure **14e**.

MS (EI): *m*/*z* (%) = 186 (100) $[M]^+$, 187 (15) $[M + 1]^+$, 185 (69) $[M - 1]^+$, 171 (23), 170 (20), 144 (39).

7-Methyl-3-(1-methyl-1*H*-pyrrol-2-yl)-2-(methylsulfanyl)-4,5-dihydro-3*H*-azepine (15e)
White solid; yield: 4.16 g (56%) after rough separation on alumina; 2.51 g (34%) after purification on alumina, followed by separation with HCl; mp 77–79 °C.

IR (KBr): 3108, 3027, 2992, 2969, 2947, 2937, 2923, 2911, 2893, 2864, 2853, 2808, 2725, 1631, 1611, 1607, 1567, 1533, 1493, 1464, 1443, 1430, 1413, 1377, 1364, 1347, 1326, 1302, 1283, 1245, 1231, 1191, 1173, 1152, 1123, 1081, 1059, 1049, 1039, 1006, 976, 911, 887, 861, 846, 803, 786, 778, 708, 692, 684, 670, 622, 609, 580, 535, 499, 476, 460 cm^{-1}.

^1H NMR: δ = 1.88, 2.01 (2 m, 2 H, CH_2-4), 1.94 (s, 3 H, Me-7), 2.24 (s, 3 H, SMe), 2.37, 2.60 (2 m, 2 H, CH_2-5), 3.38 (s, 3 H, NMe), 4.02 (dd, $^3J_{3,4}$ = 12.4 Hz, $^3J_{3,4'}$ = 7.0 Hz, 1 H, H3), 5.32 (t, $^3J_{6,5}$ = 7.0 Hz, 1 H, H6), 6.07 (m, 1 H, H3′), 6.11 (dd, $^3J_{4',3'}$ = 3.3 Hz, $^3J_{4',5'}$ = 2.9 Hz, 1 H, H4′), 6.61 (dd, $^4J_{5',3'}$ = 1.8 Hz, 1 H, H5′).

$^{13}C_{jmod}$ NMR: δ = 19.93 (SMe), 22.14 (Me-7), 23.12 (C4), 33.38 (NMe), 40.98 (C5), 42.23 (C3), 106.75 (C4′), 108.59 (C3′), 110.43 (C6), 122.46 (C5′), 130.13 (C2′), 147.75 (C7), 174.48 (C2).

^1H–^{15}N HMBC: δ = –230.7 (N-pyrrole), –73.6 (N-azepine).

MS (EI): *m*/*z* (%) = 234 (100) $[M]^+$, 235 (17) $[M + 1]^+$, 187 (40), 186 (20), 145 (47), 112 (77).

2-Methyl-6-(1*H*-pyrrol-1-yl)-3*H*-azepine (14f)
Scale: 27.4 mmol; THF–DMSO, 5.0:1; *t*-BuOK (1.1 equiv); yellowish-brown solid; yield: 0.67 g (14%) after rough separation on alumina; 0.17 g (4%) after subsequent purification on alumina; mp 57–59 °C.

IR (KBr): 3093, 2977, 2910, 1699, 1619, 1571, 1547, 1534, 1512, 1484, 1428, 1389, 1369, 1315, 1308, 1286, 1263, 1254, 1220, 1212, 1191, 1146, 1108, 1075, 1071, 1018, 979, 955, 938, 914, 882, 865, 835, 819, 763, 741, 729, 714, 708, 667, 631, 622, 613, 569, 507, 432, 406 cm^{-1}.

^1H NMR: δ = 1.25, 2.68 (2 m, 2 H, CH_2-3), 2.18 (s, 3 H, Me-2), 5.47 (dt, $^3J_{4,5}$ = 8.6 Hz, $^3J_{4,3}$ = 7.3 Hz, 1 H, H4), 6.27 (br t, $^3J_{3',2'(4',5')}$ = 1.8

Hz, 2 H, H3′, H4′), 6.38 (d, $^3J_{5,4}$ = 8.6 Hz, 1 H, H5), 6.89 (br t, $^3J_{2',3'(5',4')}$ = 1.8 Hz, 2 H, H2′, H5′), 7.57 (br s, 1 H, H7).

$^{13}C_{jmod}$ NMR: δ = 26.37 (Me-2), 38.45 (C3), 109.67 (C2′, C5′), 117.49 (C3′, C4′), 120.78 (C7), 125.25 (C5), 130.18 (C6), 132.87 (C4), 149.95 (C2).

MS (EI): *m*/*z* (%) = 172 (100) $[M]^+$, 171 (34) $[M - 1]^+$, 157 (27), 156 (18), 130 (30).

7-Methyl-2-(methylsulfanyl)-3-(1*H*-pyrrol-1-yl)-4,5-dihydro-3*H*-azepine (15f)

White solid; yield: 2.26 g (38%) after rough separation on alumina, followed by separation with HCl; 0.68 g (11%) after subsequent purification on alumina; mp 30–32 °C.

IR (KBr): 3101, 3095, 3028, 2964, 2951, 2923, 2888, 2870, 2850, 1714, 1687, 1629, 1574, 1542, 1515, 1487, 1447, 1438, 1431, 1408, 1376, 1351, 1327, 1314, 1294, 1280, 1256, 1229, 1184, 1134, 1095, 1076, 1062, 1045, 1036, 1007, 985, 966, 916, 891, 873, 840, 822, 790, 723, 678, 650, 626, 586, 531, 506, 469, 405 cm^{-1}.

^1H NMR: δ = 1.93, 1.94 (2 d, $^4J_{Me,6}$ = 1.22 Hz, $^4J_{Me,6}$ = 1.19 Hz, 3 H, Me-7), 1.97, 2.05 (2 m, 2 H, CH_2-4), 2.22 (s, 3 H, SMe), 2.54 (tt, $^2J_{5,2'} \approx {}^3J_{5,4}$ = 12.7 Hz, $^3J_{5,3'} \approx {}^3J_{5,6}$ = 7.3 Hz, 1 H, CH_2-5), 2.75 (tdd, $^2J_{2',5} \approx {}^3J_{2',3'}$ = 12.7 Hz, $^3J_{2',6}$ = 7.9 Hz, $^3J_{2',4}$ = 2.2 Hz, 1 H, CH_2-5), 5.00 (dd, $^3J_{3,4}$ = 12.1 Hz, $^3J_{3,3'}$ = 7.1 Hz, 1 H, H3), 5.32 (ddq, $^3J_{6,5}$ = 7.8 Hz, $^3J_{6,2'}$ = 5.6 Hz, $^4J_{6,Me}$ = 1.2 Hz, 1 H, H6), 6.21 (t, $^3J_{3',2'(4',5')}$ = 2.1 Hz, 2 H, H3′, H4′), 6.70 (t, $^3J_{2',3'(5',4')}$ = 2.1 Hz, 2 H, H2′, H5′).

$^{13}C_{jmod}$ NMR: δ = 12.49 (SMe), 21.86 (C4), 22.19 (Me-7), 40.89 (C5), 61.82 (C3), 108.46 (C3′, C4′), 110.08 (C6), 121.16 (C2′, C5′), 147.44 (C7), 172.44 (C2).

^1H–^{15}N HMBC: δ = –219.2 (N-pyrrole), –74.9 (N-azepine).

MS (EI): *m*/*z* (%) = 220 (100) $[M]^+$, 205 (64), 163 (43).

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