Palladium catalysed cyclisation-Barbier-type allylation cascades

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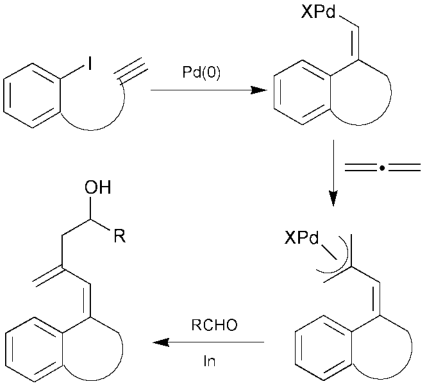
Pd(0) catalysed termolecular queuing processes involving cyclisation of aryl halides onto proximate alkynes, allene (1 bar) insertion, transmetallation of the resulting π-allylpalladium(II) species with indium and addition to an aldehyde affords heterocyclic and carbocyclic dienes.

Our ongoing development of palladium catalysed polycomponent cyclisation-queuing processes has provided powerful methodology for the construction of carbocyclic and heterocyclic rings with accompanying substantial increases in molecular complexity.[1]



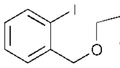
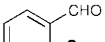
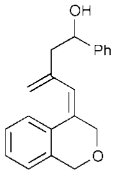
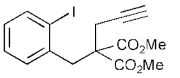
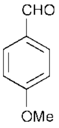
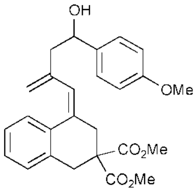
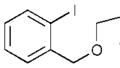
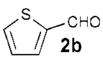
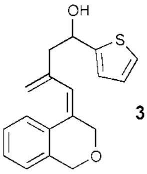
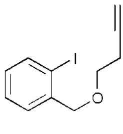
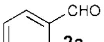
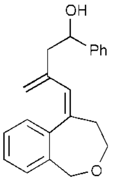
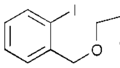
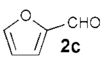
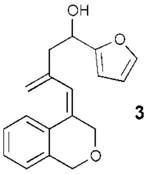
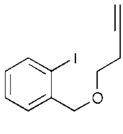
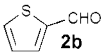
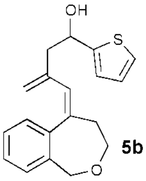
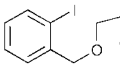
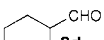
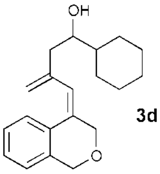
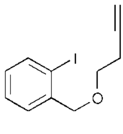
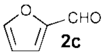
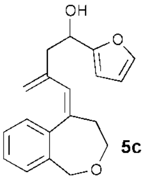
Scheme 1

Recently we reported the palladium–indium mediated Barbier-type allylation of aldehydes with allenes[2] and identified four synthetic variants of this Pd–In mediated reaction depending on whether the Pd or In step was *intra*- or *inter*-molecular.

We now describe the incorporation of this reaction into a palladium catalysed cyclisation-termolecular queuing cascade. This cascade involves palladium catalysed cyclisation of an aryl iodide moiety onto proximate alkynes followed by allene insertion.[3] The resulting π-allylpalladium(II) species then undergoes transmetallation with indium metal generating an allylindium species which subsequently adds to the aldehyde component, affording heterocyclic and carbocyclic dienes (Scheme 1). Marshall and Grant have described transmetallation of allenylpalladium(II) species (sp^2-C–Pd) with indium salts[4] and very recently a report of the transmetallation of conventionally generated π-allylpalladium(II) species with In(I) and In(III) halides has appeared.[5]

Reaction (DMF, 84 °C, 8–16 h, Schlenk tube) of alkynes **1a–c** (1.0 mmol) with allene (1 bar), aldehydes (1.0 mmol) and indium powder (1.6 mmol) in the presence of a catalytic system comprising 10 mol% $Pd(OAc)_2$ and 20 mol% tris(2-furyl)-phosphine afforded the expected six- and seven-membered

Table 1

Alkyne	Aldehyde	Product	Yield(%)[a]	Alkyne	Aldehyde	Product	Yield(%)[a]
 **1a**	 **2a**	 **3a**	52	 **1b**	 **2e**	 **4**	54
 **1a**	 **2b**	 **3b**	51	 **1c**	 **2a**	 **5a**	46
 **1a**	 **2c**	 **3c**	50	 **1c**	 **2b**	 **5b**	53
 **1a**	 **2d**	 **3d**	46	 **1c**	 **2c**	 **5c**	53

[a] Isolated yield.

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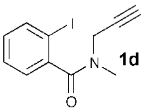
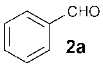
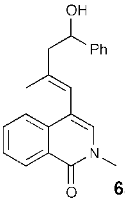
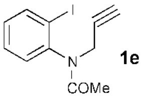
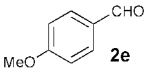
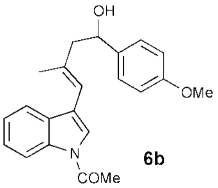
Table 2

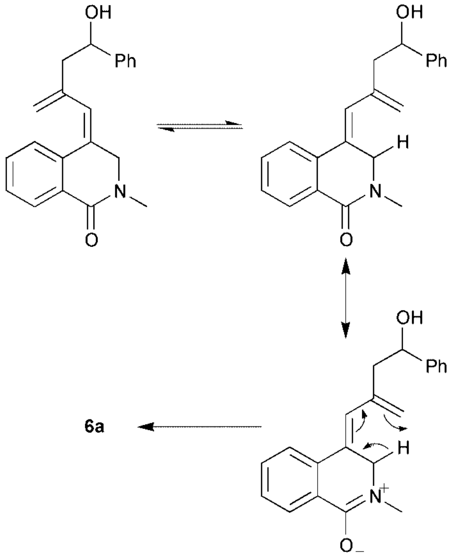
Alkyne	Aldehyde	Product	Yield(%)
 **1d**	 **2a**	 **6a**	43
 **1e**	 **2e**	 **6b**	43

carbo- and hetero-cyclic products with aromatic, hetero-aromatic and aliphatic aldehydes. Products of alkene isomerisation were not detected under these conditions (Table 1).

We next turned our attention to alkynes **1d** and **1e** (Table 2). When these compounds were subjected to the same reaction conditions as **1a**–**c** the expected cascade ensued but the resulting products, **6a** and **6b**, were the isomeric conjugated dienes.

A possible mechanism, which explains the formation of **6a** and **6b**, is shown in Scheme 2. The driving force for the proposed 1,5-H shift is the developing aromaticity in the rearrangement transition state. This latter factor is absent in **3a**–**d**, **4** and **5a**–**c**.

These reactions further emphasise the versatility of the palladium–indium cascade process. There is clearly considerable scope for variation of the carbonyl and allene components and further developments are in hand.



Scheme 2

We thank the EPRSC and Leeds University for support.

Notes and references

1 R. Grigg and V. Sridharan, *J. Organomet. Chem.*, 1999, **576**, 65.
2 U. Anwar, R. Grigg, M. Rasparini, V. Savic and V. Sridharan, *Chem. Commun.*, 2000, 645.
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