

3-Ethylcarbazole as a building block for new OLED host materials achieving EQEs over 20%

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INTRODUCTION & AIM

In recent years, organic light-emitting diodes (OLEDs) have garnered significant academic and industrial attention due to advantages ranging from innovative product design possibilities to highly efficient and sustainable light sources, creating an ever-growing demand for new high-performance materials. Addressing this need, we have developed four new D-A-D type host materials, namely **CzeCzS**, **eCz2S**, **CzeCzM**, and **eCz2M**, which combine carbazole electron donors with either diphenylmethanone or diphenyl sulfone electron acceptors, as well as one or two ethyl chains to potentially improve film forming properties. All materials demonstrated the ability to form stable amorphous layers with high glass transition temperatures, as proven by differential scanning calorimetry (DSC) experiments. Spectroscopic analysis confirmed that all four compounds exhibit high triplet energies, making them suitable as host materials for green phosphorescent and yellow thermally activated fluorescence (TADF) emitters. Device studies revealed that the methanone bridged hosts consistently outperformed their diphenylsulfonyl counterparts, delivering higher current density, luminance, and efficiency with best device incorporating **CzeCzM** compound as a host for green phosphorescent OLED device achieved an external quantum efficiency (EQE) of 16.5%. Furthermore, implementing blended co-host architectures markedly improves device performance, significantly enhancing external quantum efficiency and suppressing efficiency roll-off. Co-hosted device utilizing methanone-based host material **eCz2M** achieved peak EQE value of 20.3%. These findings demonstrate both the intrinsic advantages of methanone derivatives as hosts and the synergistic benefits of co-host designs in achieving high-performance OLEDs.

MOLECULAR STRUCTURES

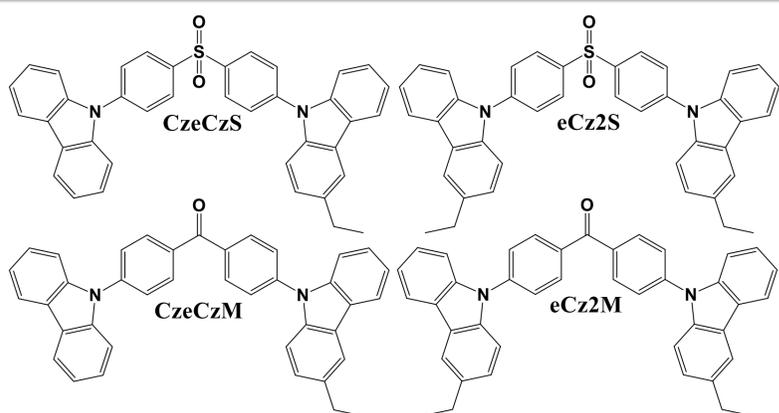


Figure 1. Structure of newly synthesized ethylcarbazole-based host materials

THERMAL AND MORPHOLOGICAL CHARACTERIZATION

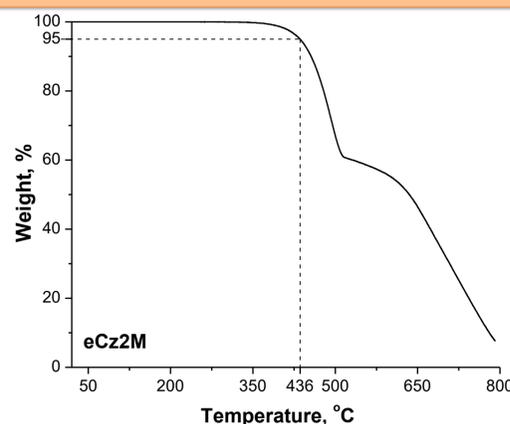


Figure 2. Thermogravimetric analysis

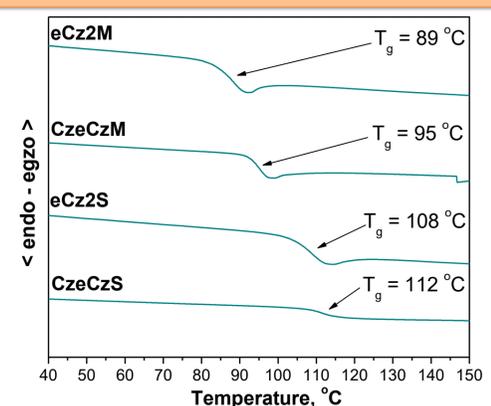
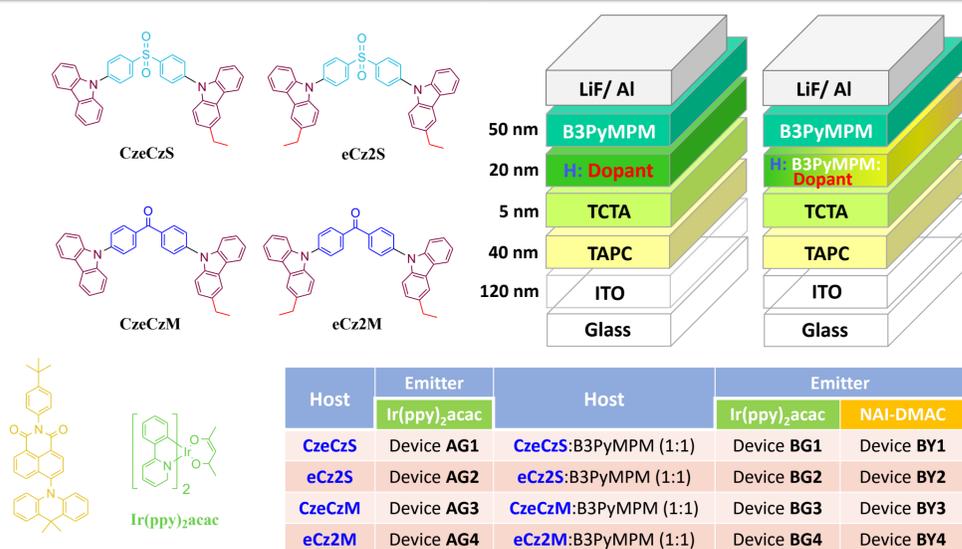


Figure 3. Differential scanning calorimetry

OLED CHARACTERIZATION



Host	Emitter	Host	Emitter
CzeCzS	Device AG1	CzeCzS:B3PyMPM (1:1)	Device BG1
eCz2S	Device AG2	eCz2S:B3PyMPM (1:1)	Device BG2
CzeCzM	Device AG3	CzeCzM:B3PyMPM (1:1)	Device BG3
eCz2M	Device AG4	eCz2M:B3PyMPM (1:1)	Device BG4

Table 1. EL characteristics of green-emitting devices using different hosts in the EML.

Device	AG1	BG1	AG2	BG2	AG3	BG3	AG4	BG4
EQE (%)	[a]	10.7	14.8	14.0	19.0	16.5	20.2	15.7
	[b]	8.5	12.2	9.7	16.1	15.2	19.1	13.2
CE (cd/A)	[a]	38.7	53.0	50.1	69.0	59.4	72.5	55.4
	[b]	30.9	43.7	34.7	58.4	54.6	68.5	46.5
PE (lm/W)	[a]	50.6	69.4	60.5	90.3	77.9	103.5	72.6
	[b]	29.9	45.1	33.3	58.4	63.4	81.8	50.2
V _{on} (V)	[c]	2.4	2.3	2.5	2.3	2.2	2.2	2.3
λ _{max}	[b]	528.0	529.0	529.0	529.0	523.0	523.0	523.0

Figure 4. Structures the materials used and schematic structures of the fabricated OLEDs.

CONCLUSIONS

Four new ethylcarbazole-based D-A-D host materials **CzeCzS**, **eCz2S**, **CzeCzM**, and **eCz2M** were successfully synthesized using one- or two-step nucleophilic aromatic substitution routes and evaluated for their suitability in OLED applications. Thermal and morphological analyses showed that all four materials are highly resistant to degradation, with decomposition temperatures ranging from 393 to 436 °C, and they form stable amorphous films with high glass transition temperatures (89–112 °C). Photophysical measurements revealed consistently high triplet state energies (2.71 – 2.90 eV), indicating that these compounds can effectively serve as hosts for both green phosphorescent and yellow TADF emitters. Device studies further highlighted clear structure to performance relationships: the methanone-bridged hosts outperformed their phenylsulfonyl analogues due to more balanced charge transport and improved exciton confinement. When applied as host materials to green phosphorescent emitter, the newly synthesized phenylsulfonyl and methanone derivatives achieved maximum EQEs of 14.0% and 16.5%, respectively. Furthermore, incorporating these hosts into blended co-host architectures led to notable efficiency enhancements, reduced efficiency roll-off, and external quantum efficiency values surpassing 20%. The best-performing device, based on the **eCz2M**:B3PyMPM co-host system, achieved an EQE of 20.3%, a luminance efficiency of 72.7 cd/A, and a power efficiency of 95.1 lm/W and the efficiency was retained even in higher luminance with EQE of 19.1% at 1000 cd/m² for **CzeCzM**:B3PyMPM based device. Also, for yellow emitting TADF OLED prototype our co-host systems enabled to achieve an EQE of 10.3%. Overall, this work demonstrates that methanone-bridged ethylcarbazole D-A-D structures are strong candidates for next generation high-performance OLED host materials. The combined insights into molecular design, thermal and morphological stability, excited-state properties, and device characteristics provide fundamental knowledge for developing advanced host materials for both TADF and phosphorescent OLED technologies.

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