



## Review

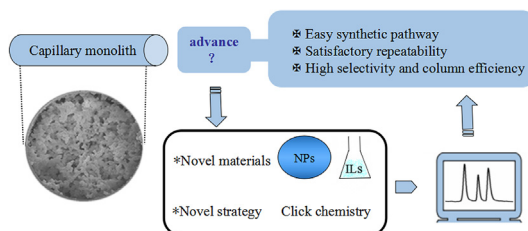
## Recent advances in the preparation and application of monolithic capillary columns in separation science

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## HIGHLIGHTS

- Preparation of novel monolithic capillary columns have shown powerful potential in analytical chemistry field.
- Various materials including ionic liquids and nanoparticles involved into capillary monolithic micro-devices are concluded.
- Click chemistry strategy applied for preparing monolithic capillary columns is reviewed.
- Recent strategies utilized in constructing different capillary monoliths for enantiomeric separation are summarized.
- Advancement of capillary monoliths for complex samples analysis is comprehensively described.

## GRAPHICAL ABSTRACT



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## ABSTRACT

Novel column technologies involving various materials and efficient reactions have been investigated for the fabrication of monolithic capillary columns in the field of analytical chemistry. In addition to the development of these miniaturized systems, a variety of microscale separation applications have achieved noteworthy results, providing a stepping stone for new types of chromatographic columns with improved efficiency and selectivity. Three novel strategies for the preparation of capillary monoliths, including ionic liquid-based approaches, nanoparticle-based approaches and “click chemistry”, are highlighted in this review. Furthermore, we present the employment of state-of-the-art capillary monolithic stationary phases for enantioseparation, solid-phase microextraction, mixed-mode separation and immobilized enzyme reactors. The review concludes with recommendations for future studies and improvements in this field of research.

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<b>Abbreviations</b>	
AM	acrylamide
AHs	aromatic hydrocarbons
AGE	allyl glycidyl ether
AMC	affinity monolithic chromatography
AHA	6-azidoheptanoic acid
AAs	amino acids
ADMPC	amylose-3,5-dimethylphenylcarbamate
[APMIm]Cl	1-aminopropyl-3-methylimidazolium chloride
AGIs	$\alpha$ -glucosidase inhibitors
ATA	11-azido-3,6,9-trioxadecan-1-amine
[bmin]BF <sub>4</sub>	1-butyl-3-methylimidazolium tetrafluoroborate
BMA-EDMA	butyl methacrylate-ethylene dimethacrylate
BSA	bovine serum albumin
BHb	bovine haemoglobin
CEC	capillary electrochromatography
cLC	capillary liquid chromatography
[C <sub>4</sub> mim][BF <sub>4</sub> ]	1-butyl-3-methylimidazolium tetrafluoroborate
[C <sub>4</sub> mim][Tf <sub>2</sub> N]	1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide
CNTs	carbon nanotubes
$\beta$ -CD	$\beta$ -cyclodextrin
CuAAC	copper(I) catalysed (3 + 2) azide-alkyne cycloaddition
CDMPC	cellulose tris(3,5-dimethylphenylcarbamate)
CLIP	clindamycin phosphate
DPEPA	dipentaerythritol penta-/hexa-acrylate
DART-MS	direct analysis in real time mass spectrometry
EOF	electroosmotic flow
EDA	ethylenediamine
EP	ephedrine
GN	grapheme
GO	graphene oxide
GMA-EDMA	glycidyl methacrylate-ethylene dimethacrylate
GSH	glutathione
GNPs	gold nanoparticles
Gd-DTPA	gadolinium-diethylene triamine pentaacetic acid
HILIC	hydrophilic interaction chromatography
HPLC	high performance liquid chromatography
HAS	human serum albumin
HRP	horseradish peroxidase
IL	ionic liquid
IMER	immobilized enzyme reactor
ICP-MS	inductively coupled plasma mass spectrometry
IMAC	immobilized metal ion affinity chromatography
IPTMS	3-iodopropyl-trimethoxysilane
In <sub>2</sub> O <sub>3</sub>	indium oxide
LC	liquid chromatography
LODs	limits of detection
MBA	<i>N,N'</i> -methylenebisacrylamide
MWCNTs	multi-walled carbon nanotubes
MOAC	metal oxide affinity chromatography
MOF	metal-organic framework
MSA	[2-(methacryloyloxy)ethyl]-dimethyl-(3-sulfopropyl)-ammonium hydroxide
MPTS	mercaptopropyltrimethoxysilane
MAH	<i>N</i> -methacryloyl-L-histidine methyl ester
$\gamma$ -MAPS	$\gamma$ -methacryloxypropyltrimethoxysilane
MPS-OVS3	3-mercapto-1-propanesulfonate modified octavinylsiloxane
MIP	molecularly imprinted polymer
NPs	nanoparticles
NHSG	non-hydrolytic sol-gel
NSAIDs	non-steroidal anti-inflammatory drugs
NaTiNTs	sodium titanate nanotubes
OT	open-tubular
OTA	ochratoxine A
PSP	pseudo-stationary phase
POSS	polyhedral oligomeric silsesquioxanes
PMPMS	poly-3-mercaptopropyl methylsiloxane

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