US009410210B2

(12) **United States Patent**
Mach et al.

(10) **Patent No.: US 9,410,210 B2**
(45) **Date of Patent: *Aug. 9, 2016**

(54) **FILTRATION METHODS AND DEVICES**

(76) Inventors: **Patrick A. Mach**, Shorewood, MN (US); **Raj Rajagopal**, Woodbury, MN (US); **Wensheng Xia**, Woodbury, MN (US); **Jinsheng Zhou**, Woodbury, MN (US); **Chunmei Guo**, Woodbury, MN (US); **Guoping Mao**, legal representative, Woodbury, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 392 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/701,935**

(22) PCT Filed: **Jun. 6, 2011**

(86) PCT No.: **PCT/US2011/039242**

§ 371 (c)(1),
(2), (4) Date: **Apr. 26, 2013**

(87) PCT Pub. No.: **WO2011/156258**

PCT Pub. Date: **Dec. 15, 2011**

(65) **Prior Publication Data**

US 2013/0344488 A1 Dec. 26, 2013

Related U.S. Application Data

(60) Provisional application No. 61/352,205, filed on Jun. 7, 2010.

(51) **Int. Cl.**

C12Q 1/68	(2006.01)
C12Q 1/04	(2006.01)
G01N 33/68	(2006.01)
B01D 63/00	(2006.01)
C12Q 1/24	(2006.01)

(52) **U.S. Cl.**

CPC ***C12Q 1/689*** (2013.01); ***B01D 63/00*** (2013.01); ***C12Q 1/04*** (2013.01); ***C12Q 1/24*** (2013.01); ***G01N 33/68*** (2013.01); *B01D 2323/39* (2013.01)

(58) **Field of Classification Search**

USPC 435/34, 6.12, 7.1; 210/321

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,342,328	A	9/1967	Swenson	
4,539,256	A	9/1985	Shipman	
4,726,989	A	2/1988	Mrozinski	
4,867,881	A	9/1989	Kinzer	
4,920,105	A	4/1990	Zelman	
5,120,594	A	6/1992	Mrozinski	
5,242,595	A *	9/1993	Morgart et al.	210/636
5,260,360	A	11/1993	Mrozinski et al.	
5,443,727	A	8/1995	Gagnon	
5,506,279	A	4/1996	Babu et al.	
5,766,868	A	6/1998	Seto	
5,770,086	A	6/1998	Indriksons et al.	
5,993,954	A	11/1999	Radovanovic et al.	
6,096,213	A	8/2000	Radovanovic et al.	
6,106,483	A	8/2000	Guirguis	
6,171,689	B1	1/2001	Kaytor et al.	
6,461,724	B1	10/2002	Radovanovic et al.	
6,517,709	B1	2/2003	Cardwell et al.	
6,669,981	B2	12/2003	Parsons et al.	
6,861,067	B2	3/2005	McGhee et al.	
7,140,496	B2	11/2006	Nagoya et al.	
7,993,523	B2 *	8/2011	Chen	B01D 39/1623 210/321.6
2003/0217965	A1	11/2003	Kools	
2004/0063169	A1 *	4/2004	Kane	C12Q 1/24 435/30
2004/0157971	A1	8/2004	Kim	
2005/0067343	A1	3/2005	Zulauf et al.	
2005/0244943	A1 *	11/2005	Ladisch	C12Q 1/24 435/252.3
2006/0062854	A1	3/2006	Chandra et al.	
2007/0111194	A1	5/2007	Pellaux et al.	

FOREIGN PATENT DOCUMENTS

CN	1800038	7/2006
JP	56-158144	12/1981
KR	10-2004-0040692	5/2004
WO	WO 2006/069307	6/2006
WO	WO 2007/146722	12/2007
WO	WO 2010/071764	6/2010
WO	WO 2010/078234	7/2010
WO	WO 2011/152967	12/2011
WO	WO 2011/153085	12/2011
WO	WO 2011/156251	12/2011

OTHER PUBLICATIONS

Lenntech. Bubble Point. Downloaded from the Lenntech website on Jul. 23, 2014: <http://www.lenntech.com/library/fine/bubble/bubble-point.htm>.*

Field, R.W. et al. Critical Flux Concept for Microfiltration Fouling. Journal of Membrane Science 100 (1995). Elsevier. pp. 259-272.*

* cited by examiner

Primary Examiner — Kagnew H Gebreyesus
Assistant Examiner — Nghi Nguyen

(57) **ABSTRACT**

A method of filtering a liquid sample that includes passing a sample comprising at least one biological organism through a filter membrane at a passive water volume flux of at least 10 $L/m^2 \cdot h \cdot psi$, wherein the filter membrane comprises a Bubble Point pore size of no more than 1.0 μm, thereby retaining at least one biological organism on the surface of the membrane; and detecting the at least one biological organism retained on the surface of the filter membrane.

24 Claims, 6 Drawing Sheets