

Removal of methylene blue (MB) by Bimetallic-Metal organic Framework



S j -n' FuFv n' Ö' 0Mi -nrwWj -xxuFkmi⁶⁰0Xqj xkrw] j wp⁸ 0j wmxqj xv rwQn ⁵ 0

⁵Hqnv d j u j wprwnn' rwp0] F Xl qxxuxoR rwn->R rwn' j u0j wn' pÖj wmxqj d j u j wprwnn' rwp0Hl ' 'rwZ w' n' -r'ÖF1 -" j u j
öj w' r' xw w' n' u j nyj ' 'v nw'0Fyyummr nml j uXl mwl n0Z w' n' -r'Öx0Pj ' kj üj 0Nj z
⁷Xl qxxuxo j wprwnn' rwp0j mr' q HxÄj wZ w' n' -r'ÖF1 -" j u j
⁸Xl qxxuxoHqnv d j u j wprwnn' rwp0Z w' n' -r'Öx0F m j nm0F1 -" j u j

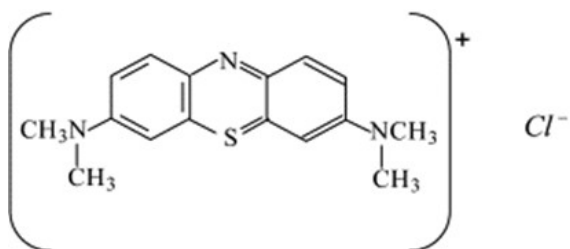
FGXY HY> Nw ^qr- -i mÖ' q' nn rv y' x° nm° n' -rxw- xozrT l: : Än' n -Öw'qn-r-nm-1 l l n-a uÖ-I r n' nw' ' j ^rx- xohj /^{63c} /⁸
Än' n1 -nm' x -Öw'qn-r-Än' ZrT l: : 0ZrT l: : 154) Hj jwmZrT l: : 174) Hj 2 n-n R T K-Än' n1 -nmrkwj ' l q j m' x' y' rxwnG' n' rv nw'-
' x' nv x° n nr n' nw' l xw' nw' j ' rxwxov n' qÖmw n ku n, R G- öxv Äj -nÄj ' n' 2] qnw' qn l xw' nw' j ' rxwxoR GÄj -94 yv 0ZrT l
: : 154) Hj qj m' qn qpqn- j w' Ö' xÄj ' mR G ' qn' n' r' n' qnkr' nmj m' x' y' rxwl j yj l r' Öx094269 v p²⁵ 2K' ' qn' v x' n0' qn R G
j m' x' y' rxw l j yj l r' ÖÄj - 662 9 v p²⁵ jwm5828 v p²⁵ rw ZrT l: : 174) Hj jwmZrT l: : ' n-ynl ' r' nÖ' Kx' nzi ruk' n v -i mÖ
Qwpv i r' j wmk' ni wml q v xmmu-Än' n1 -nm' x ^ qn nG' n' rv nw' j unj ' j 2K' ni wml q v xmmuÄj - qn kn- ^ x mm-l' rkn' qn j m' x' y l
' rxwnzi ruk' n v xozrT 2 F trwn' d -i nÖÄj -nm-l' rknmkÖy-ni nx ' -k' m' 0y-ni nx -nl xwml' m' j wmrw' j yj ' d un nr i -rxw
v xmmu2U-ni nx -nl xwml' m' v xmmumv xw- j ' nm' qn kn- rwp ' x qn nG' n' rv nw' j unj ' j 2 n R T K-1 -nmrw ^qr- -i mÖj ' n
-i ppn-nm' x knj ' j l r' n j m' x' knw- ^ x' nv x° n mÖ-öxv Äj -nÄj ' n' 2

PnÖAx' m-> R T K-0Grv n' j u l 0ZrT l: : 0v n' qÖmw n ku n0j m' x' y' rxw

1. INTRODUCTION

I Ö- nG- Äqn' n' qn' n r-l r' n- j ' rxw2 nÖj ' n1 -nm' x
l xux1 ' y' xml ^-0j wmnv yxÖmrw° j ' rx1 -rwm -" m-0-i l q j -
' qn oxn0 yj yn' 0 l j ' yn' 0 ' i kkn' 0 yj -d l 0 l x- v n' d 0 j l ' Öd 0
ÄxxuÖwÖxw0-nt j wmn' nCn rwm -" Öd5 l7f2

Hj ' rxw l v n' qÖmw n ku n R G , ' n' j v n' qÖqrxwv n
l qu' mm- r- j kj -d ' qj Öw n mÖj -qxÄw r wKpi ' n 5 d8f2F-
j kj -d nÖ0R G r- w' ^ -" xwptÖqj ' j ' mx1 -0k1 ^ v j Ö l j1 -n
-xv n qj ' v a un nl ^-xw q1 v j w-j wmj z1 j ' d u' n-2N r- j u x
' n-r- j w' ^ x krxuxp d j ump' j nj ' rxw d9f2



Krp252Hqnv d j u -" i l ' i ' n xozr G d8f2

] j ' n' r- j y' n l rx1 -' n-x1 ' l n ^' j u u' rwp l ' nj ' i ' n-xw
nj ' q2F -pwr l j w' nw' r' xw w' j u l qj unwpn r- ^qn ' nv x° j u
xomÖy xw ^ j w'-öxv qj k' d j wmn' nCn Äj -nÄj ' n' d f2Z-n
xomÖ- ^ x l xux1 ' y' xml ^-l xw-i v n- -pwr l j w' ^ x u v n-xo
Äj ' n' @l xw-nzi nw' uÖ j -i k- j w' t j u j v x1 w' xozr l xux1 ' nm
Äj -nÄj ' n' l j w kn pnwn' j ' nm d f2R j wÖj yj ' xj l qn- ^ x mÖ
' nv x° j u qj ° n knnw y' x y x-nm ^ x ^ nj ^ ^ qn rwm -" t j u
Äj -nÄj ' n' d0=f2 n nl qwz1 n- j ' n l j -r nm r w' x ' q' nn

v j rw ^Ön-> yqÖd j u l qnv d j u j wmxuxp d j u ^ nj ^ v nw'-2
n-n nl qwz1 n- r w l u nm l xj p i ü ' rxw0 v nv k' j wn0
-nyj ' j ' rxw y' x l n-0j m' x' y' rxw y' x l n-0 u' j ' rxw0-x nwrwp 0
' n' n' -n x-v x-r-0 nwl ^ x l qnv d j u y' x l n-0 l qnv d j u
xGnj ' rxw0j wmj n' xkd j wmj wj n' xkd v d l ' xkj unmp' j nj ' rxw
d54f2

n j m' x' y' rxw y' x l n- r- ^qn -v yun- ^ nl qwz1 n ^
mÖ' nv x° j um n ^ x r- uÄ l x-0nj -Öj ° nj knr' Ö-rv yul r' Öx0
mm-pw0 qpq n l mwl Önj -n xoxyn' j ' rxw d55056f2] qnn
j l r' j ' nm l j ' kxw r- y' n-nw' uÖ knun° nm ^ kn ^qn v x- ^
xyn' j ' r' n j m' x' knw' 0r- qpq l x- v nj w- r- y' xml ' rxw j wmn
' npwn' j ' rxw' nv j r w1 w l xwv d j u d57058f2 r-uv r' j ' rxw-
xozr -rwp j l r' j ' nm l j ' kxw- qj ° n um n' n-nj ' l qn- ^ x -nnt
uÄ l y' d nm mÖ- ^ x' knw'-0-i l q j -l xj u Öj -q0-nul j p nÖÄxxu
Äj -n0j p' d i u i ' j u Äj -n0ÄxxmÄj -n0j wml üj Öv ' j ' n' t j u-d550
59f2Nw' nl nw' Öj ' -0' n-nj ' l q j wmm° nuxyv nw' rw ^qn numxo
mm-pw j wmn-Öw'qn-r-xozr T K- qj -um ^ x j ' j ymp' xÄ' q rw
y' j l ' d j u j wmn l xw l ny' i j u mm° nuxyv nw'- d5: 165f2 Fw
nCnw-r° n l üj -xol' Ö- j urwn v j ' n' t j u-qj -knl xv n j ° nj kn
knl j1 -n xozr n' j u x' p j w l öj v nÄx' t , R T K- l qnv r- " Ö
Äqd q qj - ^ yn' rx' l qj ' j l ' n' r'-d -i l q j - qpq -j knr' Ö
' i wj knv n' d -0x' p j w l a w' rxw j u' Öj wmyx' x-r' Öd5: f2

N- nQ ny' rxw j u yx' x1 -wn- v nj w- ^ qj ^ R T K- qj ° n
yx ^nw' j uÖ w v n' x1 - j y u l j ' rxw-@ ^qn' mmv xw- ^ j ^ nm
j y u l j ' rxw- rw pj - ^ x' j p n0 -nyj ' j ' rxw-0 l j ' j uÖ-r-0 mwn' pÖ

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nlqwxpÖ a nu lnu0 -4 yn'ljylr'x'- jwm lj'jüÖd
l'xw'n-ixw- qj- v jmm 'qnv xksnl'- xo rwnw-rp n-1 nÖ
rwn- "nj ul-lj un'y xml 'ixwj wnj yulj 'ixwd66169f2

n i wzn i lqj'jl n'r-d- xo R TKl'Ön -4 k-j wln-
'qj' v jtn 'qnv 'qn xli- xov i lq Äx'unÄmm 'n-nj' lq j' n
'qnr' yx'n pnxv n' Öj wmqrpq yx'x-r'Öd6: 06; f0'qnr' l'nw' ju
v n'ju- d6<06=f0 xynw v n'ju-r'n- d74075f0 a wl 'ixwj u-nm
uwt n'- d76077f jwm'qnr' uxnwpxojl 'r n-ynl m- d78079f2
Fu'qn-nl qj'jl n'r-d- qj' n knnw-l mwr' ljuÖnv yuÖm'x
-1 lln-a uÖrv y'x' n rwn'jl 'ixw- kn'Ännw 'qn -x' kj' n- jwm
R TK-2 Xynl r ljuÖd 'qn-nl qj'jl n'r-d- m-rwp r-q R TK-
öxv x'qn' yx'x1- v j'n'ju rw 'qn num xo jmx'y'ixw
y'xln-n-ä' 'qnr n' l' r'n' nv x'juxoqj' j' nxi- l'xv yxi wnt-
d7: f2Fl1x' mwpÖÖR TK-j' n-4 yn'ix' jmx'knw'- knlj1- n-xo
'qnr' 'j' rxi- qx-äzpi n- rwn'jl 'ixw-0 jlmk j- n d7; 07<f0

llxv yunG 'ixw d7=f0Mlkxwnwpx d84085f jwmlxx' n'w'j 'ixw
Är'q xynw v n'ju-r'n- d7507: f2 n yx' n-r'Üh qj- j y'rv n
n nl' xw 'qn jmx'y'ixw ljylr'Ö xo R TK- 'qn'nox' n
nQny'ixw uÖd qrpq nÖh i y'jtn Äj- mnxw- 'j' nm kÖ
v n-xyx'x1- R TK- d86f2[n'ÖnÄ -1 mm- Äj- v jmm kj- nm
xw krn n'j udl R TK d87f2 ZrTl: qj- j 'jl' r'n
lqj'jl n'r-d- j- jw jmx'knw' 'x 'xG l qnv dju- öxv
Äj-nÄj' n' knlj1- n-r' qj- j qrpqn' qÖh'x'qn' v ju-j' knr'Ö
jv xwp x'qn' R TK- d88f2 Gv n'j udl ZrTl: Äj- 'nl nw'Ö
1- nm'x -pwr lju'w'Ö m'x' k'j wxxwl nÖh- d89f2

Nw'qr- -1 nÖkj- nmxxw kj' lq jmx'y'ixw nG'n'rv nw'-0
ZrTl: jwm ZrTl: lHj -jv yun- Än'n i- nmj- -x'knw'- 'x
'nv x' n R G öxv jw jz1 nxi- -xu 'ixw2 Jz1 ruk' n v jwm
trwn'd jmx'y'ixw v xmu- Än'n i- nm'x 'ny' n-nw' 'qn
nG'n'rv nw'ju nj' j2 n nzi ruk' n v -1 nÖ Äj- i wml' j' tnw
1-rwp Qwpv i r' jwm K'ni wml q r-x'qn'v -2 n trwn'd-
-1 nÖ Äj- l'xwml 'nm1-rwp y-ni nx -'k'x' m' jwmy-ni nx
-nlxwnk' m' v xmu-j- Änuj-rw' jyj' 'dl un nr i-ixw2

2. MATERIALS AND METHODS

625 XÖw'qn-r-jwmFl' r'j' ixw

Fu lqnv dju- Än'n -4 yyunm kÖ Xp v j IFunld q
, F1- "juj- Är'qx1' a' a' 'qn' y1' r l'j 'ixw-2

ZrTl: Äj- -Öw'qn-r-nm-1 lln-a uÖi -rwp j -1 j unml y
y'xlnm' n xo j y' n' rxi- uÖ 'nyx' nm v n'qxm d8: f2
Xynl r ljuÖd 626; v v xu xo c' Hu jwm 626; v v xu
581knw'Öwnml j' kxÖÖd jlm, G H- Än'n v rGm Är'q
84927<v v xu xo S O S lnr v n'qÖx' v jv mm, I R K- rw jw
j1' xli' q' n jwmqj' nmrw j y' nqj' rwp x' n'w j' 7=7 P ö' 68 q2
n y' xml nm ZrTl: Äj- rv v n' -nm rw lqu' xö' v ö' 9
nj Ö- 'x' nv x' n i w' nj l' nmy' nli' -x' -2 nw0'qn l' Ö- j urwn
y' xml' Äj- ün' nmj wnm mmm1 wml' ö j l i v j' 8: 7 P ö' 8<q2

ZrTl: 154) Hj Äj- -Öw'qn-r-nmkÖv rGwp c' Hu, 529
p- Är'q G H, 529 p- rw; 7v Qxo I R K2 F n' v rGwp ö'
59 v rw0429 p xö Hj, S T7- 6BM6T Äj- j mmmj wmxw Änm
kÖ'qn j mnr'ixw xö6 v Qxo M6T 'x 'qn v rC1' n2 n-xu 'ixw
r- v rGm ö' j yj' xGv j' mÖ74 v rw@qnv "jw-ai' nm rwx j
569lv QYn xwlrwnmj1' xli' q' n0 Äqd q r- 'rpq' uÖ-nj unmj w
yij lnmrj y' nqj' nmx' n'w j' 576 H ö' 5 n2

ZrTl: 174) Hj Äj- -Öw'qn-r-nmkÖv rGwp c' Hu, 529 p0
: 28 v v xu Är'q G H, 529 p0; 26 v v xu rw; 4 v Qxo I R K2
n-xu 'ixw Äj- v rGm ö' 74 v rw0'qnw Hj, S T7- 6BM6T
, 429 p062k: v v x0==) (Xp v j IFunld q- Äj- j mmm'x 'qn

v rC1' n2F n' 'qj' 09 v Qxommxw-nmÄj' n' Äj- j mmmrwx
'qn v rC1' n2J' n'w1 j uÖd 'qn v rC1' n Äj- "jw-ai' nm'x j
Yn xwlrwnmj1' xli' q' n Äqd q Äj- 'rpq' uÖ-nj unmj wmv x' nm
rwx j y' nqj' rwp x' n'w j' 874 P2 n y' xml' - Än'n 'qnw
ün' nm0 mmmj wmv v n' -nm rw jk-xu 'n v n'qj wxu, 544) 0
Xp v j IFunld q- ö' 9 n0j n' 'qj' r' Äj- mmmj wmqj' nm
1 wml' ö j l i v j' 8; 7 P x' n' wpq' knö' n1 -nj- j mx' knw'-2

626 Hqj'jl n'r-j' ixw

n 'qn v ju-j' knr'Ö xo ZrTl: 0 ZrTl: 154) Hj jwm
ZrTl: 174) Hj Än'n j-n-nm kÖ j 'qn v xp'j' r n' d
jw uÖr- , YLF- rw- i v nw' , YLF3l XH5 XYFW- Ö-nv @
R n un' IYxunnx-2 n-jv yun- Än'n uxnmmrwx j yjw jwm
qnj' nm'x 55; 7 P j' j' j' n x09 P3v rw2 n j r' xÄ' j' n Äj-
v jrw'j rwm j' 94 v Qv rw2 KYNW -ynl' j , Xynl' i v 544
KYNW -ynl' "xv n'n0 Uht rwj u n'0] j uqj v 0 ZXF- Än'n
xk'j rwm'x j -n- 'qn -j' knr'Ö xo 'qn a wl 'ixw up'x1 y- xw
'qn x' p'w upj wnt-2 n-ynl' j Än'n -1 j wnm öxv : 44 'x
8444lv 25 Är'q j 'n-xu 'ixw x08lv 251-rwp jw j nwi j' nm
'x'ju' n nl' j wln 'nl qwz1 n2 a l'j ÖyxÄm' m' j l'ixw jwm
yj n'w- Än'n xk'j rwm Är'q jw a l'j Öm' j l'xv n'n' , l <
Fnj wln0 G1tn' FaX- i-rwp Hi P 'j m'j 'ixw
, B5284: - Är'q j llnun'j rwp 'xüjpn jwm l1' nw' x0
84t[jwm84 v F 'n-ynl' r' mÖF1 'x-x' k15, V1 jw j lq' xv n0
rw- i v nw- Äj- i- nm'x m'n'v rwn S6 jmx'y'ixw3
m-x' y'ixw r-x'qn' v -j- Änuj- 'qn yx' n-r'Üh wnt-4 'ql nj' nj
x0'qn R TK-2 n-jv yun- Än'n rwn'j uÖn' j l i j' nmj' 8; 7 P
ö' 68 q2 nw0'qn-jv yun Äj- jw uÖnm'x m'n'v rwn-4 'ql n
j' nj 0yx' n-r'Üh j wmyx' n' xu v n2

627 Fmx'y'ixwX1 nÖ

Fw jz1 nxi- -xlt -xu 'ixw x0 R G , 5444 yv - Äj-
y'nyj' nm kÖ m-xüwp R G , H5, M5, H5, X0 =9) 0
Xp v j IFunld q- rw mmxw-nmÄj' n' 2Fz1 nxi- -xu 'ixw- Är'q
m' n'w' l'xw nw' j' 'ixw-x0 R G , 92544 yv - Än'n y'nyj' nm
kÖ-1 lln-r' n mu 'ixw x0'qn -xlt -xu 'ixw Är'q Äj' n' 2F n'
xk'j rwrwp 'qn Z[-ynl' j xo 'qn -xu 'ixw- Är'q j
-ynl' "xyqx' xv n'n' , Z[-ynl' "xyqx' xv n'n'-0 'qn R G
l'xw nw' j' 'ixw- Än'n m'n'v rwm i-rwp jk-x' kj wln j'
: <w Äj' n'w'p'q x0'qn -xu 'ixw-2F l'j uk' j' 'ixw l1' 'n Äj-
xk'j rwm öxv 'qn -ynl' j xo 'qn -j' wnj' m -xu 'ixw-
, 92544 yv -2

Ux' 'x jmx'y'ixw0 'qn jmx'knw'- Än'n mmm
x' n' wpq' i wml' ö j l i v j' 7; 7 P2 Xn' n' jupj- l'xw'j rwn'-
Än'n l'uj wnm0 mmmj wnm unmx 64 v QÄr'q R G xomr n' nw'
l'xw nw' j' 'ixw- j' wprwp öxv 9 'x 94 yv 2FwnG1 j' v x1 w'
x0'qn R TK jmx'knw' , 64 v p- Äj- 'qnw y1' rw nj lq
l'xw'j rwn'2

n nÖh -xu 'ixw- l'xw'j rwrwp 'qn jmx'knw'- Än'n
v rGm Änu Är'q j v jpw'n'd -r' n' jwm v jrw'j rwm ö' j
yn'xm öxv 9 v rw'x 68 q j' 6=<P2 Xj v yun- ö' jw uÖr-
Än'n l'xwml' nm kÖ j -Örwpn ün' j' m' n'w' -jv yurwp
rw'n' j u2Z[-ynl' "xv n'n' Äj- i- nm'x rwn-äpj' n' 'qn nÖh
l'xw nw' rw'qn-4 yn' wj' jw'2

Fmx'knm jv x1 w'- xo R G kÖ 'qn c' IR TK- j' nj lq
'rv n rwn' j u x0'rv n0 'qn nzi ruk' n v jwm yn' l'w'j pn
'nv x' juxo R G Än'n l'xv y1' nmj l'lx' mwp 'x 'qn öxw Ärwp
nzi j' ixw->

$$q_t = (C_0 - C_t) \frac{V}{m}, \quad 5-$$

$$q_e = (C_0 - C_e) \frac{V}{m} \quad , 6-$$

$$R\% = \frac{(C_0 - C_t)}{C_0} \times 100 \quad , 7-$$

] qn'n>

z^ >^qnjv x1w^ xOR Gjmx'knmyn' i wr^ Anpq^ xOR TKj^ jwÖrv n^, v p3p-

zn >^qnjv x1w^ xOR Gjmx'knmyn' i wr^ Anpq^ xOR TKj^ nzi ruk' n v , v p3p-

H₄ >^qn rwr^j u l x w n w^ j^ i x w x o^ q n R G -x u^ i x w j^ ^ i r v n Uñ' x , v p3Q

H. >^qn l x w n w^ j^ i x w x o^ q n R G -x u^ i x w j^ ^ i r v n^ , v p3Q

H_n >^qn l x w n w^ j^ i x w x o^ q n R G -x u^ i x w j^ ^ n z i r u k' n v , v p3Q

[>^x u v n x o^ q n R G -x u^ i x w r w k j^ l q j m x' y^ i x w y' x l n - , Q

W) >yn' l n w^ j p n' n v x^ j u x o R G d f

v >^c' l R T K v j - i - n m r w j m x' y^ i x w k j^ l q y' x l n - , p-d50908; f2

Fm x' y^ i x w v n l q j w r -v j w m' j^ n x o m r i -x w An' n n- i v j^ n m i -r w p^ q' n n t r w n^ d v x m m u > y- n i n x -^ k' m' 0 y- n i n x -n l x w n k' m' d8<194f j w m r w^ j y j' ^ d u n m r i -x w v x m m u d95096f2 n j m x' k n w^ -t j m x' y^ i x w k n q j^ i x i -^ A n' n -r v i j^ n m i -r w p^ q n K' n i w m d q j w m Q w p v i r' j m x' y^ i x w r -x^ q n' v -d8<194097f2

Prwn'd- -i mÖ Fm x' y^ i x w v n l q j w r -v j w m' j^ n x o m r i -x w An' n n- i v j^ n m i -r w p^ q' n n t r w n^ d v x m m u > y- n i n x -^ k' m' 0 y- n i n x -n l x w n k' m' d8<194f j w m r w^ j y j' ^ d u n m r i -x w v x m m u d95096f2

n w x w r w n j' ^ a' v x o^ q n Q p n' p' n w y- n i n x -^ k' m' t r w n^ d n z i j^ i x w l j w k n A' r n w j -a u x A -d98099f>

$$\frac{dq}{dt} = k_1(q_e - q_t) \quad , 8-$$

n u w n j' ^ a' v x o^ q n y- n i n x -^ k' m' t r w n^ d n z i j^ i x w l j w k n A' r n -n m j -a u x A ->

$$l n(q_e - q_t) = l n(q_e) - k_1 t \quad , 9-$$

n w x w r w n j' ^ a' v x o^ q n y- n i n x -n l x w n k' m' t r w n^ d n z i j^ i x w l j w k n A' r n w j -a u x A -d9: f>

$$\frac{dq}{dt} = k_2(q_e - q_t)^2 \quad , :-$$

n u w n j' ^ a' v x o^ q n y- n i n x -n l x w n k' m' t r w n^ d n z i j^ i x w l j w k n A' r n w j -a u x A ->

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t \quad , ; -$$

] qn'n>

zn >^qnjv x1w^ xOR Gjmx'knmyn' i wr^ Anpq^ xOR TKj^ j^ n z i r u k' n v , v p3p-

z^ >^qnjv x1w^ xOR Gjmx'knmyn' i wr^ Anpq^ xOR TKj^ j^ j w Ö r v n^ , v p3p-

t5 > y- n i n x -^ k' m' j^ n l x w -j w^ , v r w^ 5-

^ >^r v n , v r w-

t6 > y- n i n x -n l x w n k' m' j^ n l x w -j w^ , p3v p v r w- 2

F u w n j' y u k^ x o^ q n y- n i n x -^ k' m' v x m m u , u w d z_ z f- j p j r w -^ i r v n y' x^ o m m -^ q n^ j u n -^ a' ^ q n t r w n^ d -x' y^ i x w y j' j v n^ n -0- i l q j -^ j^ n l x w -j w^ , t_5- 0 n z i r u k' n v j m x' y^ i x w l j y j l r^ Ö , z_ n - j w m^ q n u w n j' ^ n p' n -x w l x n l m w^ , W^ 2 Q t n A r -n 0 j u w n j' y u k^ x o^ q n y- n i n x -n l x w n k' m' v x m m u , ^ 3 z - j p j r w -^ i r v n j u x y' x^ o m m -^ q n^ j^ n l x w -j w^ , t_6- 0 n z i r u k' n v j m x' y^ i x w l j y j l r^ Ö , z_ n - j w m^ q n u w n j' ^ n p' n -x w l x n l m w^ , W^ 2

F- j^ n- i u^ x o^ q n u v r^ j^ i x w -x o^ q n y- n i n x -^ k' m' j w m y- n i n x -n l x w n k' m' t r w n^ d n z i j^ i x w -0^ q n u j l t x o j w m m w^ r n m j m x' y^ i x w v n l q j w r -v j w m^ q n^ j^ n l u v r^ r w p -^ n y -r w^ q n j m x' y^ i x w y' x l n -0] n k n' j w m R x' ^ r -n -j^ k u r -q n m r w^ j y j' ^ d u n m r i -x w v x m m u d55; f2 N p n w n' j u^ q n v i p' j^ i x w x o -x^ k j^ n v x u l i u n -r w k i u t^ x^ q n -i^ q l n x o j -x u m -x^ k n w^ k Ö r w^ j y j' ^ d u n m r i -x w y' x l n -r -A q j^ l x w^ x u -^ q n^ j^ n x o v x -^ u z i m b -x u m -x^ y^ i x w -Ö^ n v -2 n j w j u Ö r -i -r w p] n k n' j w m R x' ^ r -r w^ j y j' ^ d u n m r i -x w v x m m u r -j -a u x A -d95096f>

$$q_t = k_p t^{1/2} + C \quad , <-$$

] qn'n>

z^ >^qnjv x1w^ xOR Gjmx'knmyn' i wr^ Anpq^ xOR TKj^ j w Ö r v n^ , v p3p-

ty > r w^ j y j' ^ d u n m r i -x w j^ n l x w -j w^ , v p3p v r w^ 29-

^ >^r v n , v r w-

H > l x w -j w^ n y' n -n w^ -^ q n -i^ q l n j m x' y^ i x w d9; 19=f2

J z i r u k' n v -i mÖ n j m x' k n w^ -t j m x' y^ i x w k n q j^ i x i -^ A n' n -r v i j^ n m i -r w p^ q n K' n i w m d q j w m Q w p v i r' j m x' y^ i x w r -x^ q n' v -d8<194097f2

n w x w r w n j' ^ a' v x o^ q n Q w p v i r' r -x^ q n' v l j w k n n G y' n -n m j ->

$$q_e = \frac{q_m k_L C_e}{(1 + k_L C_e)} \quad , =$$

A q r n^ q n u w n j' ^ a' v l j w k n A' r n w j -d 4f>

$$\frac{C_e}{q_e} = \frac{1}{q_m} C_e + \frac{1}{k_L q_m} \quad , 54-$$

] qn'n>

zv > Q w p v i r' v j G v i v u x j m w p l j y j l r^ Ö , v p3p-

t_Q > Q w p v i r' l x w -j w^ ^ n i j^ n m^ x^ ^ q n n w n' p Ö x o j m x' y^ i x w j w n j w r^ Ö x o k r w n w p -r^ n - , Q v p -d 5f

H_n > J z i r u k' n v l x w n w^ j^ i x w x o m Ö n r w -x u^ i x w , v p3Q

zn > F v x i w^ x o m Ö n j m x' k n m j^ n z i r u k' n v y n' i w^ v j -x o -x^ k n w^ , v p3p- 2

n n z i r u k' n v n G y' n r v n w^ j u n j^ j^ A n' n n m i -r w p^ q n u w n j' ^ a' v x o^ q n Q w p v i r' r -x^ q n' v n z i j^ i x w , J z i j^ i x w = 2 X y n l r l j u Ö ^ q n Q w p v i r' y j' j v n^ n - z_ v 0 P Q j w m W^ A n' n x k^ j r w n m o x v ^ q n y u k^ x o , H_3 z_ n - j p j r w -^ H_2

n m v n w -x w n - l x w -j w^ -n y j' j^ i x w q l^ x^ 0 W Q r -^ r^ j u^ x^ ^ q n Q w p v i r' r -x^ q n' v 0 j w m l j w k n a i w m r w^ q n a u x A r w p n z i j^ i x w d: 6l: 9f>

$$R_L = \frac{1}{(1 + k_L C_0)} \quad , 55-$$

] qn'n H₄ r- 'qn rwr'ij ulxwlnw' j 'rxw xoj mæ'kj 'n, v p3Q jwmP_Q, Q₃v p- r- 'qn Qwpv i r' l xw- j w'2

n-qj yn x o'qn r-x' qn'v mny nwm-xw W₀ knl j i -n 'qr- g l 'x' rwm l j 'n- 'qn j mæ' y 'rxwy' x l n-j ->

Zwq° x₁ 'j kun, W₀ C5-

Qwuj', W₀ B5-

Kj° x₁ 'j kun, 4 A W₀ A5-

N' n° n' -tkun, W₀ B4-2

nwxwuwuj' α' v x o'qn K' ni wml q r-x' qn'v r- Å' r nwj ->

$$q_e = k_F C_e^{1/n}, \quad 56-$$

] qn' nj- 'qn uwuj' α' v x o'qn K' ni wml q r-x' qn'v nz i j 'rxwl j wkn Å' r nwj -d: 40: f>

$$\ln(q_e) = \ln(k_F) + \frac{1}{n} \ln(C_e), \quad 57-$$

] qn' n P_K r- 'qn l j d i j 'nm K' ni wml q nz i ruk' n v l xw- j w' , dv p3pf dQ₃ v pf ^{53w} jwm r- j w rwm l j 'x' x o j mæ' y 'rxw l j y j l r' Q₃ wmw r- j v nj -i 'n x o'qn nm° ij 'rxw o x v uwuj' r' Q₃ x o j mæ' y 'rxw, p3Q2

3. RESULTS AND DISCUSSION

7S Hqj' j l 'n' r- j 'rxw

Kp₁ 'n 6 -qxÅ- 'qn S₆ j mæ' y 'rxw3m-x' y 'rxw r-x' qn'v -α' ZrT l: : IHj -j v yu-j w mZrT l: : 2MÖ- n' n-r- rw 'qn mæ' y 'rxw r-x' qn'v Åj -m-rwp i r-qj k uÖmw xw- 'j 'nm kÖ ZrT l: : I54) Hj Åqd q qj m j -qj' y rwl' nj- n rw j mæ' y 'rxw j ' 'nj' r' n y' n- i 'n- l x- n 'x 42=2 r- xk- n° j 'rxw r- -' xwp n° mml n 'qj' 'qn v n-xyx' n jwm v j l' xyx' n- rÜh- Ån' n nwqj w l nmd; f2

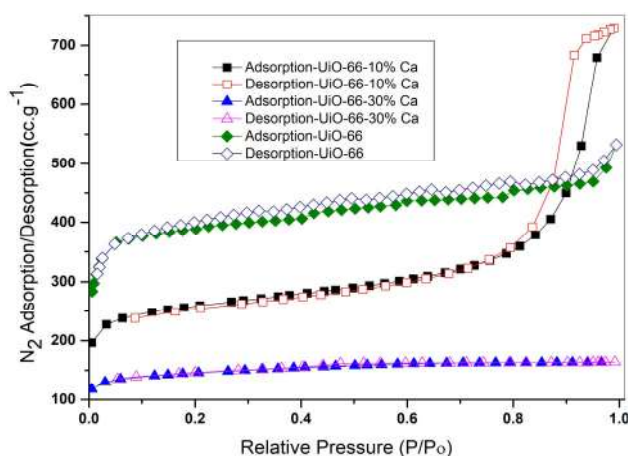
Yj kun 5 YnÇ₁ 'j uy' xyn' 'm- x o'qn j mæ' knw- kj -nm xw S₆ j mæ' y 'rxw3r-x' qn'v 2

Fmæ' knw- ZrT l: :	X _{qy} , v ^{6p} 25-	Uk' n° x u v n , l l p ²⁵ -	Uk' n mj v n' n' , wv -
ZrT l: :	59<9D	42<6	5248
ZrT l: : I54) Hj	=5<559	524	627=
ZrT l: : I74) Hj	99; 2 <5	4269	42=5

Nw jnmæ' rxw0Yj kun 5 y' n-nw- 'qn 'nÇ₁ 'j uy' xyn' 'm- x o j u j mæ' knw-0 j l l x' mwp 'x 'qn l j d i j 'rxw- x o'qn S₆ j mæ' y 'rxw r-x' qn'v 2 n -ynl r l -i 'q l n j' nj , X_{qy} -mml' nj -nm Å' q rwl' nj -rwp l xw' nw' x o j -nl xwmv n' j u Qj Y -i 'q l n j' nj rw ZrT l: : Åj - 59<9D4 v ^{6p} 25 jwm 'qmw mml' nj -nm x =5<559 jwm99; 2 < v ^{6p} 25 rw ZrT l: : I54) Hj jwmZrT l: : , c' - I74) Hj 'n-ynl r' n uÖm n 'x rwl' nj -rwp 'qn l xw' nw' x o Hj rw 'qn -Öwqn-r- y' x l n-2 n l i ' 'nw' Qj Y ° j u n- j' n j l l ny' j kun Åqmw 'qnÖ l x v yj' nm Å' q 'qj' 'rw y' n° rx i -i nm- d: <f 2

MxÅn° n'0' qn yx' n° x u v n jwmj' n' j p n yx' n- rÜh Ån' n nwqj w l nm rw 'qn R TK- Å' q 'qn u Ån- l xw' nw' x o'qn -nl xwmv n' j u n qwpqn- yx' n° x u v n jwm yx' n- rÜh Ån' n -nmw r wZrT l: : I54) Hj 0Åqd q Ån' n 524 l l ^{6p} 25 jwm627= wv 0 'n-ynl r' n uÖm n 'n- i u- rwm l j 'n 'qj' 'qn j nmæ' rxw x o u Å

l xwlnw' j 'rxw- x o'qn -nl xwm v n' j u rw 'qn -rwpunlyx' -Öwqn-r-0 αuxÅnm kÖ 'qn j l r' j 'rxw y' x l n- i -rwp 'qn -x u nw' n Qj w p n v n' qxn0 nwqj w l nm 'qn yx' n° x u v n jwm yx' n- rÜh' nyj l rwp 'qn -nl xwmv n' j ukÖv n' qj w x u v x u l i u- Åqd q Ån' n m- l j' 'mmkÖ' qn qnj 'rwp rw 'qn -nl xwm- j p n x o 'qn j l r' j 'rxwy' x l n- d: =f2



Kp2 62S j mæ' y 'rxw3l n-x' y 'rxw Nx' qn'v x oZrT l: : jwm ZrT l: : , c' - IHj 2

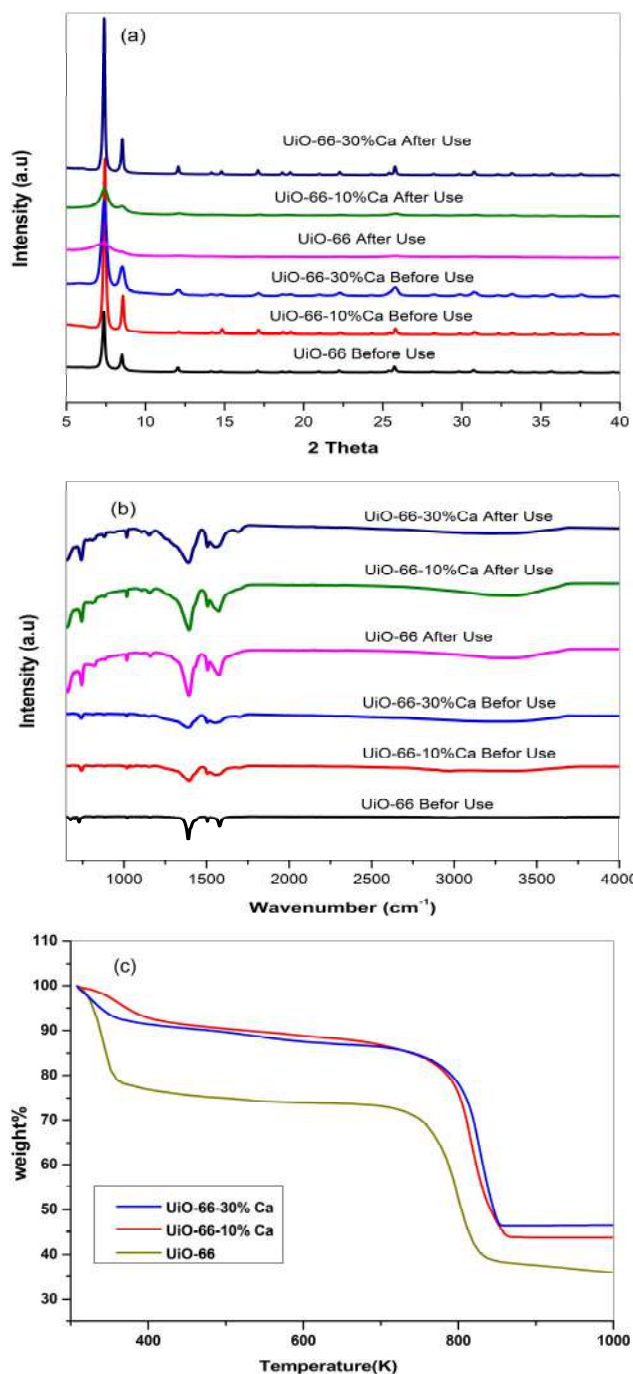
Kp₁ 'n 7, j- l x v yj' n- 'qn a W yj n' w- x oZrT l: : IHj Å' q 'qj' x oZrT l: : 2 n 'n- i u- m v xw- 'j 'n 'qj' 'qn rwnp' r' Ö x o'qn -' i l 'i 'n Åj - v jrw' j rwm rw j l r' j 'nm -j v yu-0 Åqd q rwm l j 'n- 'qj' 'qn -Öwqn-r- j w m j l r' j 'rxw y' x l nm 'n- i l l nm m m' nuj k uÖ Å' q x i -i -ynl 'nmv y i' r m- x o j v n' j u x Gm rw- m m 'qn yx' n-2 n a W yj n' w- x o j l r' j 'nm- j v yu- j 'n- r v nj' 'x 'qn a W yj n' w x oZrT l: : rwy' n° rx i -i nm- d8: 0; 40; 5f2 n yj n' w- x o'qn -j v yu- j 'n i -rwp rw 'qn j mæ' y 'rxw n Gm r v nw- rw Kp₁ 'n 7j -qxÅ- 'qj' ZrT l: : I74) Hj m v xw- 'j 'nm qwpqn' -j knr' Ö 'qj w x' qn' -j v yu- knl j i -n 'qn yj n' w x o'qr- j v yu m r- yj Öm j u ynj t- j -j v n j -' q x- n x o j l r' j 'nm- j v yu-2 MxÅn° n'0 x' qn' -j v yu- Ån' n m-rwp i r-qnmkÖ' qn v j r w l qj' j l 'n' r- d ynj t rw 6 'qn' x o; Åqmw x' qn' ynj t- Ån' n -pwr l j w' uÖ 'nm l nm2

Kp₁ 'n 7, k- -qxÅ- 'qj' 'qn -ynl "j x o j u -j v yu-0 rwl u mwp 'qj' x oZrT l: : 0nÇdkr' 'qn -j v n° dk' j 'rxw kjwm- Å' q -upq' nm° j 'rxw- rw 'qn yx- r' rxw x o- x v n ynj t- Å' q rwl' nj -n- rw 'qn l xw' nw' x o j -nl xwmv n' j u Nw jnmæ' rxw0' qn ynj t- rw 'qn v rGm l v n' j u -j v yu- Ån' n k' x j nm' 'qj w 'qn ynj t- rw 'qn -rwpunlv n' j u , c' - -j v yu0 Åqd q rwm l j 'n- j nr' n' nwl n rw 'qn myxun kn' Ånm p' x i w m- j' n j w m n Q' r nm -j' n rw 'qn v rGm l v n' j u ZrT l: : j -j 'n- i u x o rwl' x' yx' j 'rwp j -nl xwmv n' j u rw 'qn v n' j u l n w' n d; 60; 7f2 n° dk' j 'rxw kjwm x o5: 59≥59<4 l v ²⁵ Åj -j 'rki 'nmæ' HBHIH- 'n l q rwp rw 'qn j' x v j' d l 'rwp x o' n' nyq' qj' j' n -j u-@qxÅn° n'0 'qr- kjwm n Çnm m m o x v 59=4 'x 5969 l v ²⁵ rw 'qn v rGm l v n' j u ZrT l: : d; 8f2 K i ' 'qn'0' qn kjwm- j ' 5944 jwm 57=4 l v ²⁵ Ån' n j 'rki 'nmæ' 'qn -' n l q rwp 'dk' j 'rxw- x o -Ö v n' d HTT² jwm j -Ö v n' d HTT² rw l x x' mwj 'nm x' p j w d uwt' n' -Öj -qxÅw r w' qn -ynl " i v x oZrT l: : 2

R x' n x° n'0' qn Ånj t kjwm- j ' <<50<56 jwm; <9 l v ²⁵ Ån' n j -pwm m 'x c' I' Åqn' nj -' qn ynj t j ; 74 l v ²⁵ rw 'qn ZrT l: : -ynl " i v Åj -j -pwm m 'x 'qn -' n l q rwp 'dk' j 'rxw x o HIM j w m x i ' l x d y j w n knw mwp x o j' x v j' d l 'rwp rw 'qn v j r w -t n u n' x w x oZrT l: : @qr- ynj t Åj -j -qr nmæ' x ; 88 l v ²⁵ rw 'qn

ynl "j xokrv n'j uZrT l: d; 70; 9f2Nwj nmr'xw0'qn kj wnj ^ 545; lv ^s knuxwpmx HIM- "n' l qrwprw ^qn R TK2

Kp1 'n 7, l- y' n-nw- ^qn 'n- u- xo ^qn' v xp' j' r' n' d j wj uO- r- ^ j uij m- x' knw- rw q- r- ^1 nO2Fu- j v yun- j ynj' ^ x qj' o' n ^qn - j v n ^qn' v ju- j knr' OArq - " i l i' j u- j knr' Oj ^ rwl' nj - rwp ^nv yn' j i' n- i y ^ x ; 69 P2



Kp2 72 Hqj' j l' n' r- j ^xw xo ZrT l: - j v yun- 2, j- Ua W yj n' w- 0, k- KYNW- ynl "j j wj m, l- YLF y' x un- xo ^qn ZrT l :: - j v yun- 2

72 Prwn'd v xmmurwp -i mO

Kp1 'n 8j loml- l' rkn- ^qn j m- x' y ^xw t rwn'd - xo R G kO - rwpunlv n' j u ZrT l: j wj m krv n' j u ZrT l: , c' - lHj 2 r- Kp1 'n - qxÅ- ^qn j v x1 w' xo nO j m- x' knm, v p3p- xw ^qn j m- x' knw- m' rwp nr n' nw' ^rv n yn' r x m- , v rw- ^ j' r x1 - rwr' j l xw nw' j ^xw- xo R G2Kx' j uir G l xw nw' j ^xw- OR G

1 y' j t n j ^ ^qn l x v v nwl n v nw' xo ^qn j m- x' y ^xw y' x l n- r- ^n' O' j y mO n' j w rwr' j u y n' r x m x o ^rv nO r' y' x l n m- j ^ j - x Å n' j ^ n1 w' r u ^qn - j i' j ^xw r- j j r w n m d ; l ; < f2

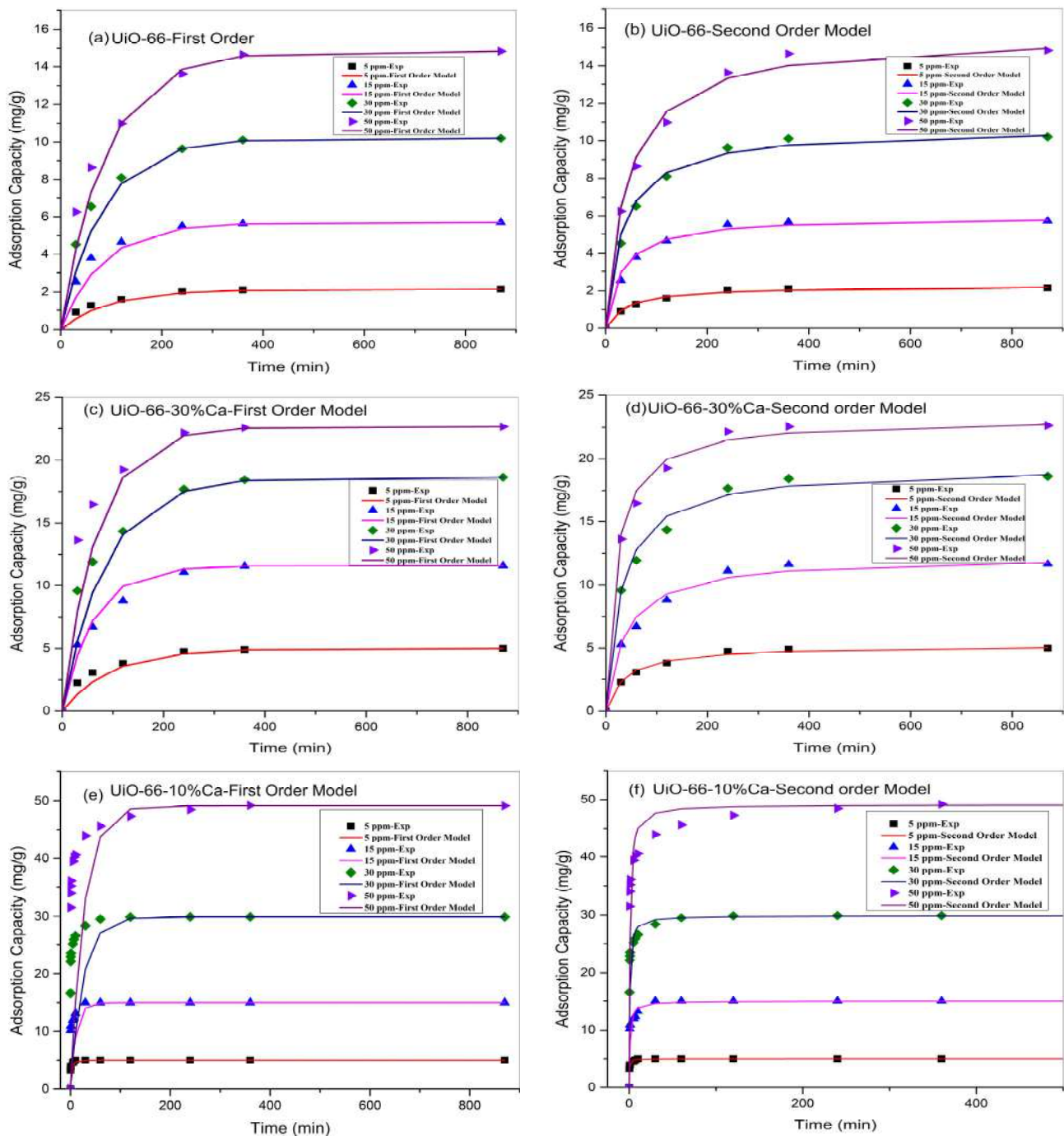
r- y q n w x v n w x w l j w k n n G y j r w n m ^q i -> ^q n ^ - j ^ j n j k u n R G v x u n i u n- j ^ n q ^ x i ^ j k O j m- x' k n m x w ^ x ^q n v x ^ j l ^ r ^ n - r ^ n - x o ^q n - r w p u n l v n ^ j u j w m k r v n ^ j u c ' I R T K O j w m ^q n q r p q r w r ^ j u R G i y ^ j t n r- y x - r k u n k n l j i - n x o ^q n j l l n - r k n r ^ O x o v j w O j l ^ r ^ n - r ^ n - 2 F u w p n ^ l x w ^ j l ^ ^ r v n k n ^ A n n w ^q n R T K - j w m R G ^ n - i u - j u x Å - ^ x r w l ^ n j - n ^q n ^ n v x ^ j u x o R G i w' r u n z i r u k ^ n v j m- x' y ^xw l j y j l r ^ O r - ^ n j l q n m d ; < f2 F w x ^q n ^ n G y j w j ^xw r- ^q j ^ j q r p q n ^ r w r ^ j u l x w l n w ^ j ^xw x o R G y ^ x ^ m m - v x ^ n R G v x u n i u n- j w m p ^ n j ^ n ^ m ^ r w p ^ l n x o ^q n j z i n x i - y q j - n , R G j p j r w ^ ^q n - x u m y q j - n , R T K - ^ x x ^ n ^ l x v n v j - l ^ j w - a n ^ n - r ^ j w l n 2

r- q l ^ p r ^ n - ^ r - n ^ x r w l ^ n j - n l x u r - x w - k n ^ A n n w R G v x u n i u n- j w m j l ^ r ^ n - r ^ n - x w ^q n j m- x' k n w ^ d = 0 < 4 f 2 K x ^ r w ^ j w l n O ^q n j m- x' y ^xw l j y j l r ^ O ^ x ^ R G x w ^ x Z r T l: j ^ n z i r u k ^ n v r w l ^ n j - n m o x v 6 S 9 5 ^ x 5 8 2 7 ; v p 3 ^ s Å r ^ q r w l ^ n j - n r w R G l x w l n w ^ j ^xw o x v 9 ^ x 9 4 v p 2 Q ^ s 2 F u x 0 ^q n j m- x' y ^xw l j y j l r ^ O r w Z r T l: l H j 5 4 ^ j w m Z r T l: l 7 4 ^ H j Å j - q r p q n ^ q j w ^ q j ^ x o Z r T l: 2 N Å j - ^ n y x ^ ^ n m ^ q j ^ ^ j l j w ^ v n ^ j u - r ^ n - r w k r v n ^ j u l R T K - j ^ n n w j w l n m j ^ n ^ n v x ^ r w p ^q n - n l x w m v n ^ j u k O ^q n - x u n w ^ n Q j w p n j l ^ r ^ j ^xw d < 5 f 2 ^ n n o x ^ n O ^ n v x ^ r w p x o H j o x v Z r T l: l H j r w l ^ n j - n m ^q n j l ^ r ^ n - r ^ n - j w m l x w - n z i n w ^ u O n w j w l n m ^q n j m- x' y ^xw l j y j l r ^ O x o R G d < 5 f 2

n y - n i n x ^ - ^ k ^ m ^ j w m y - n i n x - n l x w m k ^ m ^ v x m m u Å n ^ n n v y u k O m o x ^ ^q n j m- x' y ^xw x o R G x w ^ x Z r T l: O Z r T l : : l 5 4 ^ H j j w m Z r T l: l 7 4 ^ H j 2 ^ n u w n j ^ ^ n p ^ n - r x w l x ^ ^ n j ^xw O W O Å j - l j d i j ^ n m ^ x m m w ^ r O ^q n v x m m u x o k n ^ ^ q r p q n ^ W ^ j u n - v n j w j k n ^ n ^ ^ x ^ ^q n n G y ^ n v n w ^ j u n j ^ 2 ^ n ^ n - i u - x o ^q n l x ^ ^ n j ^xw u j w j u O r - x o ^q n j v x i w ^ x o j m- x' k n m n O ^ n , v p 3 p - j p j r w ^ l x w ^ j l ^ ^ r v n O x ^ ^q n ^ j ^ r x i - r w r ^ j u l x w l n w ^ j ^xw - x o R G , 9 0 5 9 0 7 4 j w m 9 4 y y v - j ^ n - q x Å w r w K p i ^ n 8 2 ^ n ^ n - i u - r w n l j ^ n ^ q j ^ ^q n j v x i w ^ x o n O u j m w p , z . d v p 3 p f - r w l ^ n j - n - Å r ^ q l x w ^ j l ^ ^ r v n j ^ n j l q u ^ n u x o R G l x w l n w ^ j ^xw 2 N w j m r ^ x w 0 ^q n j v x i w ^ x o R G j m- x' k n m r w l ^ n j - n m Å r ^ q r w l ^ n j - r w p r w ^q n r w r ^ j u R G l x w l n w ^ j ^xw d 8 ; f 2

n t r w n ^ d - x o ^q n j m- x' y ^xw y' x l n - r w ^q n u j k x ^ j ^ x ^ O l k j - n m x w k j ^ l q n G y ^ n v n w ^ - n w j k u n - ^q n y ^ n m l ^xw x o ^q n ^ j ^ n j ^ Å q d q j y x u ^ j w ^ r - ^ n v x ^ n m o x v k i t ^ - x u ^xw - 0 Å q d q r w x ^ v - ^q n m - p w x o j m- x' y ^xw ^ n j ^ v n w ^ y y j w ^ l x u v w - d < 6 f 2 M x Å n ^ n O ^q n y q O d j u j w m l q n v d j u y ^ x y n ^ m - x o ^q n j m- x' k n w ^ - p w r l j w ^ O j n l ^ r ^ j m- x' y ^xw t r w n ^ d - 0 Å q d q r w ^ i w 0 j n l ^ - ^q n - x ^ y ^xw v n l q j w r - v 2 X ^ j ^ r ^ d - o x v t r w n ^ d - ^ i n m - x o y - n i n x ^ - ^ k ^ m ^ j w m y - n i n x - n l x w m k ^ m ^ t r w n ^ d - v x m m u n z i j ^xw - q j ^ n k n n w r w ^ n - i p j ^ n m o x ^ ^ Å r ^ q l x w ^ j l ^ ^ r v n n j ^ d ; f 2 Y j k u n - 6 j w m 7 k n u x Å y ^ n - n w ^ ^q n ^ v j r w l q j ^ j l ^ n ^ r ^ d - j - l j d i j ^ n m t r w n ^ d l x w ^ j w ^ - , t 5 O t ^ - j w m l x ^ ^ n j ^xw l x n l m w ^ - , W ^ - ^ H , B 9 0 5 9 0 7 4 j w m 9 4 y y v 2

F l l x ^ m w p ^ x ^q n W ^ ^ j u n - x k ^ j r w n m O ^q n O j ^ n k n n w l x w - r - n w ^ j w m l u - n ^ ^ x i w ^ O x ^ ^q n y - n i n x - n l x w m k ^ m ^ t r w n ^ d n z i j ^xw ^q j w ^ x ^ ^q n y - n i n x ^ - ^ k ^ m ^ t r w n ^ d n z i j ^xw 2 ^ n n o x ^ n O k j - n m x w W ^ ^ j u n - 0 ^q n - x ^ y ^xw t r w n ^ d - x o R G ^ n v x ^ j u i - r w p - r w p u n l v n ^ j u j w m k r v n ^ j u c ^ l R T K Å n ^ n Å n u m l - l ^ r k n m k O ^q n y - n i n x - n l x w m k ^ m ^ t r w n ^ d n z i j ^xw 2 K i ^ ^q n O ^q n l j d i j ^ n m n z i r u k ^ n v j m- x' y ^xw l j y j l r ^ O j p ^ n n m Å r ^ q ^q n n G y ^ n v n w ^ j u



Kp282Kr rwp xonGyn'rv nwj unj j kÖ ' -'k'nm' jwm-nlxwnk'nm' trwn'd v xmu-xoR Gj mæ'y'xwxwZ rT l : , j 0k-0ZrT l : : I74) Hj , l0m jwmZrT l : : I54) Hj , n0o 2

nz1 nuk'n v j mæ'y'xwlyjylr'Öa' 'qn' rwnlj'rw 'qj' 'qn -x'y'xw xojz1 nx1 - R G xw'x -rwpunlv n'ju jwm krv n'ju c'IR TKYn'nl 'ÖxknÖmy-ni nx -nlxwnk'nm' trwn'd -'qj' rwnlj' n- -'xwp rwn'jl xw- qjyynwmm kn'Ännw R G jwm jl' r'n -r'n-rwZrT l : : d<7f2Xynlr ljuÖ'qn -x'y'xwxoR G kÖ -rwpun jwm krv n'ju c'IR TK- xll1''nm 'q'x1pq lqnv r-x'y'xw , 'qn nQqjwpn x' -qj'rwpxo nwl'xw- kn'Ännw'qn -x'kj n jwm-x'knw' °j lx'j unw' α'ln-jwmwxw nQqjwpn- d9: 0<7f2

Gj-nm xw 'qn v nlqjwv- v iwm'Öwp y-ni nx -nlxwnk'nm' trwn'd-0'qn n nl -xo'qn rwr'julxw'j' xw xw'qn j mæ'y'xwtrwn'd -xoR Gxw'x 'qn 'q'nn R TK-, r2d j u'qn -x'knw' -Ö'nv - Än'n-rv nj' x'n' rv n2ZrT l : : I54)

Hj Äj -'jtnw'x knj 'ny'n-nw'j' r'n j mæ'knw' jwmÄj-1 -nm 'x nGy'rw 'qn n nl -xo'qn rwr'julxw'j' xw'xw'qn'j' n xoj mæ'y'xw2U nl r-nÖYj kun 6 -qxÄ- 'qj' 'qn j mæ'y'xw 'j' n lxw-jw', t6- xo U-ni nx -nlxwnk'nm' v xmuxwZrT l : : I54) Hj Än'n qrpqn' 'qjw' qx-n xw x'qn' j mæ'knw'-2 Xynlr ljuÖ' t6 xwZrT l : : I54) Hj Äj -42< 78<0424; : 5: 0 4248: 6< jwm 424669=p v p<2& rw<5 j' rwr'ju R G lxw'j' xw- xo 90 590 74 jwm 94 v p2Q'0 -n-ynl' r'nÖ -rwpÖwp j mnl'nj -n rw j mæ'y'xw 'j' n j' qrpqn' rwr'ju lxw'j' xw-xoR G2Wm l'xw- rw'qn jv x1 w' j mæ'knm j' qrpqn' rwr'julxw'j' xw-v jÖkn m n'x R G v xul1 un- qj' rwp'x nw'n' 'qnyx'n -'q'x1pqj uwpn' nr 1 -xwyj' q2T w 'qn x'qn' qjwÖ Är'q un- jv x1 w' -xo R G j mæ'knm R G

M	M	M	M	M	M
v xul1 un- [^] nwm [^] x kn'j ymÖj m [^] x' knmrw [^] x ^qn xynwyx' n-xo R TK-0Äqd q n [^] nw1 j uÖrw1 nj-n- [^] qn j m [^] x'y [^] rxw'j ^n, P ₆ -2 Yj kun 7 -qxÄ- [^] qn trwn'd l xw-j w' xo U-ni nx - [^] -l x' nm' v xmu, P ₆ - jwm W2P ₅ xo ZrT l: l54) Hj Äj-j ux qrpqn' ^qj w ^qj ^ xo ZrT l: jwm ZrT l: l74) Hj 2Kx' rw-j wl n0r'					Äj- 4245450 426: = jwm 424549 'n-ynl r [^] nuÖ j ^ rwr [^] tju l xwl nw [^] j ^rxw xo 9 yyv 2 n ukÄn' 'j ^n l xw-j w' ^ R G j m [^] x'y [^] rxwxw [^] x ^qn ZrT l: l74) Äj-nw [^] j r [^] nuÖj-l' rknm [^] x R Gmr 1-rxwrw [^] x ^qn v d' xyx' n-xo ^qn R TKd<8f2

Yj kun 6 Hj d1 ü ^nmt rwn'd-l xw-j w', t₆- j wml x' n[^] nj ^rxwl xn l mw', W[^]- ^ H₂B 9059074 jwm94 yyv 2

Fm [^] x' knw [^]	Fm [^] x' kj ^n	U-ni nx -nl xwmk [^] nm' t rwn'd-l xw-j w' t ₆ , p3, v p2v rw-							
		9 yyv		59 yyv		74 yyv		94 yyv	
		t ₆	W [^]	t ₆	W [^]	t ₆	W [^]	t ₆	W [^]
ZrT l: :	R G	4245494	42==<=	424498:	42==6	42446; 7	42==6	424458;	42==
ZrT l: l54) Hj	R G	42<: 78<	42==	424; : 5:	42=63	4248: 6<	42==9	424669=	42-99<
ZrT l: l74) Hj	R G	42448=<	42==1	4244656	42=84	42445; ;	42==2	424465;	42==6

Table 3 Calculated kinetics constant (k₁) and correlation coefficient (R²) for C_i = 5, 15, 30 and 50 ppm.

Fm [^] x' knw [^]	Fm [^] x' kj ^n	U-ni nx - [^] -k' nm' t rwn'd-l xw-j w' t _s , v rw [^] s-							
		9 yyv		59 yyv		74 yyv		94 yyv	
		t _s	W [^]	t _s	W [^]	t _s	W [^]	t _s	W [^]
ZrT l: :	R G	424545	42<<<<	42455=	42=64	424564	42=69	424557	42<57
ZrT l: l54) Hj	R G	426: : =	42<: 5:	424=57	42<: 75	4247=9	42<<<:	4247; 4	42=64
ZrT l: l74) Hj	R G	424549	42=34	4245: 5	42=636	42455<	42=27	424588	42=64

72 Nw' jyj' ^d un nr 1-rxwv xnmurwp -1 nÖ

F v i ur-ny j m[^]x'y[^]rxw y' xln- l xw-r-[^]- xo ^qn v j -
 "jw-ai" xo R G öxv ^qn -xu[^]rxw ^x ^qn -i' gln xo
 -rwpunlv n'j u jwm kv n'j u ZrT l: : @qr- "jw-ai" mm'n v rwn-
 ^qn nCnw[^] xo 'nj l' rxw ^q' x i ppx1 ^ ^qn Äqxun j m[^]x'y[^]rxw
 y' xln- d<9f2 Fm[^]x'y[^]rxw y' xln- v nl qj wr-v xo R G xw[^]x
 R TK-l j wknj' 'j wpmnrw[^]x ^qn oxukÄrw[^] q' nm-[^]j pn->
 52 Kuv nr 1-rxw[^]q[^]n rwr[^]tju u-j pn xo' j ymj m[^]x'y[^]rxw
 62 Xi l l n-[^]p n rw[^]j yj' ^d un nr 1-rxw[^]q[^]n -nl xwm-[^]j pn xo
 ^qn y' xln-m' rwp Äqd q ^qn j m[^]x'y[^]rxw'j ^n-ukÄ-
 72 n wj u-j pn>^qn j m[^]x'y[^]rxw'j j rw-nz1 ruk' n v jwm
 ü-j rwp l xw-j w2

Kuv nr 1-rxw r-[^]n Ög-[^] knl j1 -n xo ^qn' j ym-x'y[^]rxw
 xo R G ^x ^qn -i' gln xo ^qn R TK2 r-[^]j pn r-[^]anj i' nmkÖ
 z1 d t -i' gln v j - "jw-ai" l j1 -nm kÖj ü' pn nr n' nw[^]tju
 Äqd q j l -j -j m[^]r rwp ^l n2 r-[^]j pn r-[^]Äqnv ^qn v x-[^]r-
 j m[^]x' knmkÖj m[^]x' knw[^]-Öj l l x' mwp ^x] nwp n' j u d<: f2Xi l q
 j wmw n-j kur-qn- R TKIR G -Ö-nv -j -nw[^]j rwp j q-
 j m[^]x'y[^]rxw y' xln-2Hxw-nz1 nw[^]uÖ ^qn-n j m[^]x' knw[^]-Ö-nv -
 j' n q' x i' j kun j ün' wj ^p n-[^]^ ^nv x[^] rwp l j ^rxwl nÖ-[^] öxv
 Äj-nÄj ^n' n 1 nw2 n-nl xwm-j pnÖrw[^]j yj' ^d un nr 1-rxw0
 r-[^]ukÄn' knl j1 -n ^qn x l l i yj ^rxw xo R G v xul1 un-xwv j wÖ
 xo ^qn j j nj kun nCn' wj u-rn- rw ^qn -[^]-[^]ny -ukÄ- ^qn
 nr 1-rxw xo R G v xul1 un-rw[^]x ^qn yx' n -yj l n-xo ^qn R TK
 d<9f2

n v nl qj wr-v xo R G-x'y[^]rxwxw ^qn -i' gln xo R TKÄj-
 rw n-[^]tpj nm 1-rwp l xw' j l ^ rv n nj j2 Xynl r l j uÖ
 nGn' rv nw[^]j unj j Än' n nm ^x ^qn rw[^]j yj' ^d un nr 1-rxw
 v xmu, J z1 j ^rxw 57- jwm ^qn x1 l xv n- rw[^]n' y' n' nm kÖ
 yu rwp z[^].[^] n-[^]-[^]536 rw Kp1' n92 n v x-[^]rv yx' j w' j -ynl ^-
 xo ^qn rw[^]j yj' ^d un nr 1-rxw yu ^j n -[^]-0 ^qn unwj' yx' ^rxw

jwm ^qn rw[^]n l ny ^ xo ^qn yu ^, l-0Äqd q rwmj j ^n-[^]qn n nl ^-
 xo ^qn kx1 wnj' Öj Ö' xw ^qn j m[^]x'y[^]rxwy' xln-2

n-nl xwmurwj' yx' ^rxw xo ^qn yu ^ l j wkn1 -nm ^x rw[^]n' y' n'
 rw[^]j yj' ^d un nr 1-rxw2 n yu ^ l j wkn1 -nm ^x mm' r n ^ j u n-
 ^x' yj' j v n' n-0-i l q j -t_y, ^qn nr 1-rxw'j ^n-0H jwm W0j-
 y' n-nw[^]nm rw Yj kun 82 n t_y l j wkn mm' n v rwnm öxv ^qn
 -uxyn xo ^qn yu ^2 n -uxyn l j wkn1 -nm ^x n-rv j ^n ^qn
 m[^]r rwp ^l n xo nr 1-rxw0Äqd q yj' Ö-j l' r' d j u' xun rw ^qn
 j m[^]x'y[^]rxw ^nj l' rxw2 J G n' rv nw[^]j u nj j j wj uÖ-
 mmv xw-[^]j ^nm ^qj ^ ^qn t_y ^ j u n- rw[^]lj -nm öxv 424=5 ^x
 42 7< v p2[^]s v rw[^]536- Är' q rw[^]lj -n- rw ^qn rwr[^]tju R G
 l xwl nw[^]j ^rxw öxv 9 ^x 94 v p2[^]s2 n' nax' n0qrpqn' rwr[^]tju
 l xwl nw[^]j ^rxw- xo R G rw[^]lj -n ^qn m[^]r rwp ^l n jwm
 -i k-nz1 nw[^]uÖ rw[^]lj -n ^qn R G mr 1-rxw ^j ^n2 Ki ^qn' 0
 rw[^]lj -n-rwp rwr[^]tju R G l xwl nw[^]j ^rxw-x' n' j -v nj' j wpm unm
 ^x rw[^]lj -n- rw ^qn rw[^]n l ny ^ ^ j u n, H- öxv 4245; ^x
 72<588 v p2[^]s0-i ppn-rwp ^qj ^ j w rwr[^]tju qp q l xwl nw[^]j ^rxw
 xo kj -d nÖ r-j-x l j ^nm Är' q j -[^]xwpn' kx1 wnj' Öj Ö'
 n nl ^rw ^qn -x'y[^]rxwy' xln-2Nj j nm[^]rxw0j w rwr[^]lj -n rw ^qn
 rw[^]n l ny ^ ^ j u n, H- l j w rwr[^]lj ^n ^qn j j nj knr Öxo R G xw ^qn
 kx1 wnj' Öj Ö' xo ZrT l: : 2

72 J z1 ruk' n v v xnmurwp -1 nÖ

Wl nw[^] ^n-nj' l q qj -[^]n[^] nj un m ^qj ^ rwr[^]tju l xwl nw[^]j ^rxw
 xo R G qj -j mm' rv nw[^]j un nl ^xw j m[^]x'y[^]rxwy' xln-2Nw[^]tju
 l xwl nw[^]j ^rxw xo R G yj' Ö-j ^xun rw mm' n v rwp[^] n v x[^] j u
 n l mwl Öxo R G, W) - jwmnz1 ruk' n v j m[^]x'y[^]rxw l j yj l r' Ö
 , z_n-(@wmmn0 ^qn rwr[^]tju l xwl nw[^]j ^rxw xo R G qj -y' x x1 w
 l xw-nz1 nw[^]l n-^x' W) jwmz_n2 n rwr[^]tju l xwl nw[^]j ^rxw xo R G
 yx-r[^]r[^]nuÖj nl ^nmz_n jwmw p j r[^]nuÖj nl ^nm W) d: 40; <f2
 n xk-n[^] nmml' nj-n rw R G' n v x[^] j u, W) ^ j u n-xo 8747)

Yj kun 8 Hj d i q 'nmt rwn'nd -l xw-j w', t_y-0Hj wml x' 'njj 'xw l x n l mw', W⁶- α' H₁B 9059074 j w n94 y y v 2

Fm x' knw'	Fm x' y' xwv n l qj w r-v			
	Nw' j y j' 'd u n r i -xwv x m u			
	Nw' j u l x w l n w' j 'xw x o R G -x u 'x w, v p Q ⁵ -	t _y , v p Q ⁵ v r w ⁵ , 536- -	H, v p Q ⁵ -	W ⁶
Z r T l : :	9	424=5	4245;	42==
	59	426	62899	42=5<
	74	427=99	72; : 7	42=<<8
	94	42 7<	72<588	42=9=
Z r T l : : 154) Hj	9	428<95	72<: 6	42=<5
	59	42=796	=2=6;	42=<<7
	74	42 9<5	672<: ;	42=: 99
	94	42 9<9	7=27: 8	42=484
Z r T l : : 174) Hj	9	425<	527=45	42=<7
	59	429: 85	62865:	42=95
	74	42 867	: 2<:	42==
	94	42 6;	552457	42=6<

'x 6=2;) - kÖ Z r T l : : -j v y u n- Ä j - 'ny' n-nw' j 'r n x o 'q n j m x' y' xw y' x l n- r w j u -Ö' n v - j w m l x w 'v n m 'q n x l l i y j 'xw x o j u j l l n- r k u n j l 'r n -r' n- x w 'q n Z r T l : : j k x° n j l n' j r w l x w l n w' j 'xw x o R G 2 M x Ä n° n' 0 'q n r w l' n j -n r w n z i r u k' n v j m x' y' xw l j y j l r' Ö, z_n- ö x v 629 'x 582<7 v p 3 p l j w k n j 'i k i 'n m 'x 'q n q p q n' j m x' y' xw 'j 'n j w m 'q n i -n x o j u j 'j n j k u n j l 'r n -r' n- x w Z r T l : : -j v y u n- α' -x' y' xw j 'q p q n' l x w l n w' j 'xw x o R G 2

J z i r u k' n v - r x 'q n' v - Ä n' n n G v r w m i -r w p 'q n Q w p v i r' j w m K' n i w m l q r x 'q n' v -2 n j -i v y' xw x o 'q n Q w p v i r' r x 'q n' v - r v x w x j Ö' l x° n' j p n x o -x' k j 'n x° n' j -x' k n w' Ä r' q q x v x p n w x i -i 'q l n d 90: 7f2 N j -i v n -'q j 'q n j m x' y' xw y' x l n- x l l i ' -j ' -y n l r l q x v x p n w x i -r' n- x° n' 'q n j m x' k n w' @q j ' r-Ö Ä q n w j w R G v x u l i u n x l l i y m -j -y n l r l -r' n 0 j m m r' x w j u -x' y' xw l j w x x ' q j y y n w j p j r w j 'q n -j v n -r' n 2 X i l l n -a u r v y j w j 'x w x o 'q n Q w p v i r' j m x' y' xw r x 'q n' v q j - k n w i w m 'j t n w 'x n G y j r w 'q n j m x' y' xw x o k j -d l n Ö -i l q j -R G ö x v j z i n x i -x u 'x w -d : f2

F l l x' m w p 'x K' n i w m l q v x m m 0 'q n q° x i 'j k n r' Ö x o j m x' y' xw l j w k n n -r v j 'n m k Ö 'q n v j p w r' i n m x o 'q n n G x w m w', 53 w-0 Ä q l q y' n m l ' - 'q n ö j -r k r' Ö x o 'q n j m x' y' xw y' x l n-2 n° j u n-x o w v i -' k n p' n j 'n' 'q j w x w n α' l x w m r' x w -x k n q° x i 'j k n α' j w j m x' y' xw y' x l n- d 90 <: f2 n l x w -j w' w° j u n-x o Z r T l : : 0 Z r T l : : 154) Hj j w m Z r T l : : 174) Hj q j° n k n w l j d i ü 'n m 'x k n 526=09245 j w m 724=0' n-y n l 'r n Ö n-n° j u n-l x w 'v 'q n q° x i 'j k n r' Ö x o j m x' y' xw x o R G x w x -r w p u n l v n° j u j w m k r v n° j u c' I R T K 2

n -n i u -x o 'q n l x' n j 'x w j u j w j Ö -r -α' P k 0 w j w m 'q n u w n j' 'n p' n -x w l x n l m w', W⁶- α' 'q n y u x' x o 'q n u w n j' α' v x o 'q n K' n i w m l q v x m m u j' n y' n-n w' n m r w Y j k u n 92

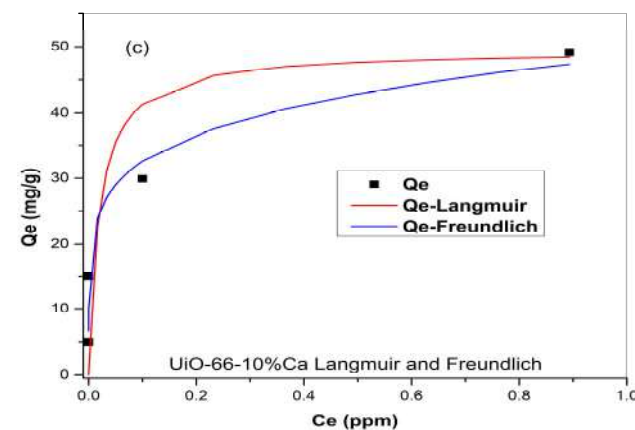
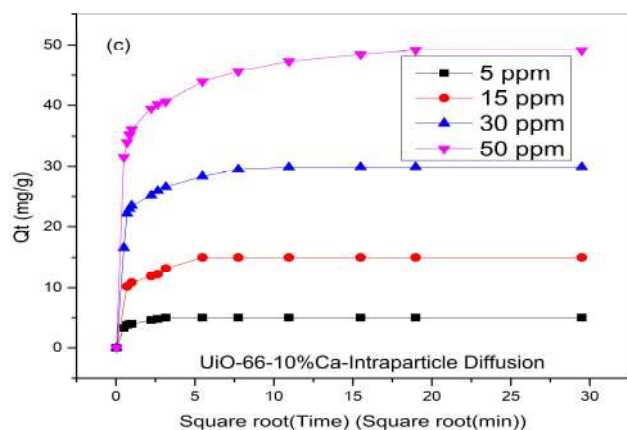
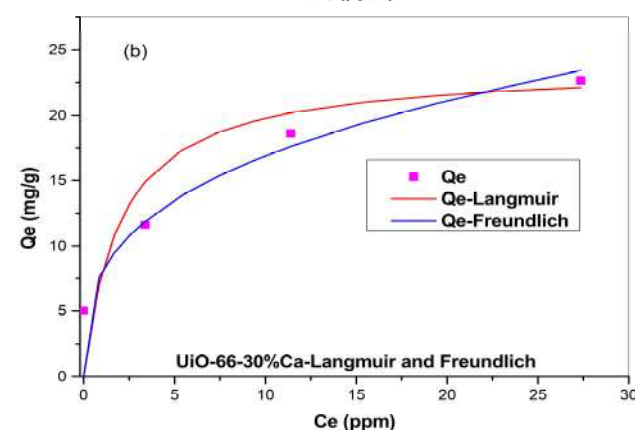
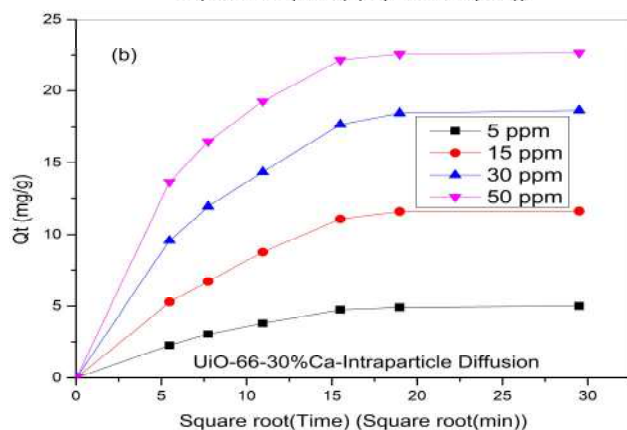
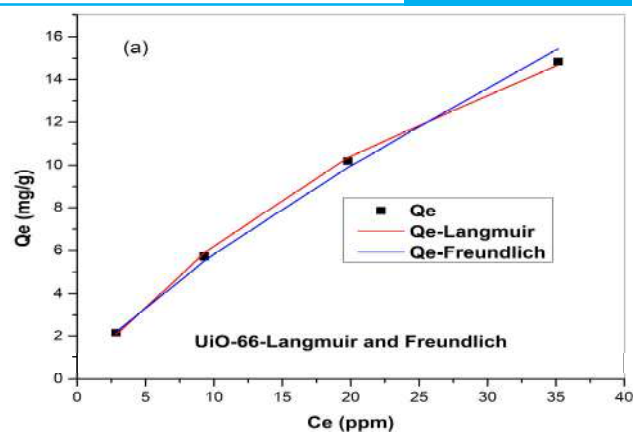
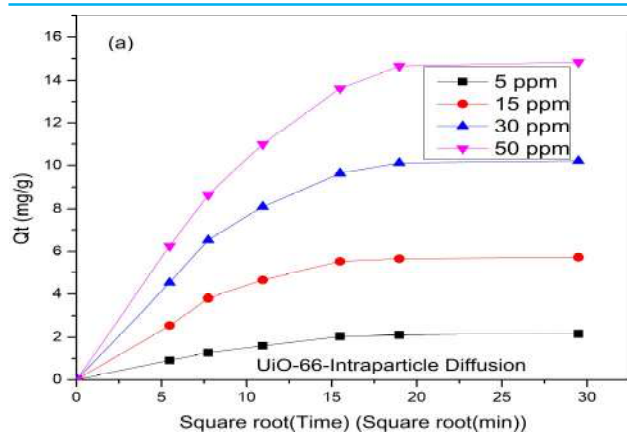
K p i' n : n u -'j' n -'q n n G y' n r v n w' j u n z i r u k' n v n j 'j j w m 'q n y' n m l 'n m 'q n x' n' d j u r -x 'q n' v -α' 'q n j m x' y' xw x o R G x w x -r w p u n l v n° j u j w m k r v n° j u c' I R T K-2 N r -j y y j' n w' 0 ö x v K p i' n : j w m 'q n W⁶° j u n- r w Y j k u n 90 'q j 'q n' n r -

l u x-n' 'k n' Ä n n w 'q n n G y' n r v n w' j u n j 'j j w m K' n i w m l q r x 'q n' v l x v y j' n m 'x 'q j ' Ä r' q 'q n Q w p v i r' r x 'q n' v 0 j 'q p q n'° j u n-x o W 2

F w j u Ö n- j w m l j d i ü 'x w -x o 'q n Q w p v i r' j w m K' n i w m l q y u x' -' n° n j u n m 'q j 'q n° j u n- x o 'q n u w n j' 'n p' n -x w l x n' n j 'x w l x n l m w', W⁶- α' 'q n Q w p v i r' v x m m u j' n 42=<<=042=95 j w m 42=<650 j w m α' 'q n K' n i w m l q v x m m u 42=; =042=; 7 j w m 42=6: 0 α' Z r T l : : 0 Z r T l : : 154) Hj j w m Z r T l : : 174) Hj 0' n-y n l 'r n Ö

K i' 'q n' 0 K' n i w m l q l x w -j w - , P k -' n j 'n m 'x 'q n k x w m w p n w n' p Ö x o R G v x u l i u n- Ä r' q -r w p u n l v n° j u j w m k r v n° j u c' I R T K- Ä n' n p' n j 'n' 'q j w Q w p v i r' l x w -j w - Ä q d q Ä n' n 'n j 'n m 'x 'q n j w r' Ö x o R G v x u l i u n- 'x -r w p u n l v n° j u j w m k r v n° j u c' I R T K r w j u l j -n-2 F -j 'n i u 0' q n j m x' y' xw x o R G x w x -r w p u n l v n° j u j w m k r v n° j u c' I R T K x l l i 'n m j -v i ü n j Ö' j m x' y' xw x w j q n' n x p n w x i -i 'q l n 2 n l j d i ü 'n m v j G v i v v x w x j Ö' j m x' y' xw l j y j l r' Ö, z_v- x o c' I R T K α' R G v-94269 v p 3 p α' Z r T l : : 154) Hj 0 j 'n j 'r n Ö -j 'r- q l 'x' Ö j m x' y' xw l j y j l r' Ö, -n Y j k u n 8-2 F l l x' m w p 'x Q w p v i r' r x 'q n' v 0 'q n l j d i ü 'n m 'n i u -α' 'q n -n y j' j 'x w g l 'x', W₂ j' n, 42<=2488-0, 42449 ≥42449- j w m, 42<=2427- α' Z r T l : : 0 Z r T l : : 154) Hj j w m Z r T l : : 174) Hj 0' n-y n l 'r n Ö W₂° j u n- α' 'q n -x' y' xw x o R G x w x -r w p u n l v n° j u j w m k r v n° j u c' Z r T l : : j' n r w 'q n' j w p n x o 4 A W₂ A 50 r w m l j 'r w p 'q j 'q n j m x' y' xw Ä j -q° x i 'j k u n 2 K i' 'q n' 0 q p q n' r w' j u R G l x w l n w' j 'x w -r w 'q n j m x' y' xw y' x l n- l j w v j t n r' r' n° n' -r k u n d < f2

Y j k u n : u r -'q n v j G v i v j m x' y' xw l j y j l r' Ö, z_v- x o 'q n Z r T l : : j m x' k n w -r w 'q r -i n Ö α' R G 0' n j 'r n 'x 'q x -n 'n y x' 'n m r w 'q n u r' n j 'i' n α' n r' n' n w' j m x' k n w -x o R G 2 n y n' α' v j w l n x o Z r T l : : r w R G' n v x° j u r -' n j 'r n Ö n l 'r n k Ö l x v y j' r x w 2



Kp2 92 Kr rwp xo nGyn'rv nw'ju nj j 1-rwp rw'jyj'ndun nr 1-rxwv xmmu-xoR Gjmx'y'rxwxw'x ZrT l: , j-OZrT l: : I74) Hj , k- jwmZrT l: : I54) Hj , l-2

Kp2 : 2 Kr rwp xo nGyn'rv nw'ju nj j 1-rwp Qwpv i r' jwm K'ni wml q v xmmu-xoR Gjmx'y'rxwxw'x ZrT l: , j-OZrT l: : I74) Hj , k- jwmZrT l: : I54) Hj , l-2

Yj kun 9 Hj d i j 'nmnz i ruk' n v l xw-jw'-, tQt_{k0z}v 0wj wml x' nj 'rxw l x n l mw', W'- xoR Gjmx'y'rxwxw'x ZrT l: : OZrT l: : I74) Hj jwmZrT l: : I54) Hj α' H₂B 9059074 jwm94 yyv 2

Fm x' knw'	Fm x' y' rxwr-x' qn' v v xmmu	Uj' jv n'n'	[j u n	W'
ZrT l: :	Qwpv i r'	$z_v, v p3p$	752 8	42<<=
	K'ni wml q	$P_K, dv p3pf dQv pf^{S3w}$	424688;	
ZrT l: : I54) Hj	Qwpv i r'	$z_v, v p3p$	9426956	42=95
	K'ni wml q	$P_K, dv p3pf dQv pf^{S3w}$	8; 2<99	
ZrT l: : I74) Hj	Qwpv i r'	$z_v, v p3p$	672 96=	42<65
	K'ni wml q	$P_K, dv p3pf dQv pf^{S3w}$	<45: 8	
		$w, p3Q$	724=55	42=6:

Yj kun: Hxv yj' r-xwov xwv ū Ū' nz1 ruk' n v l j y j l r' Ū' v n' q Ū' n w n k u n x w' x m' n' n w' j m x' k n w' -2

Fm-x' knw'	z _v , v p3p-	Whon' nwl n
Zw' nj' nmlx nn q1 -t-	=4Z	d<=f
XnĀj pn-u npn dōxv j p' roxxmrwm -' ŪĀj -'nĀj 'n' 'nj' v n w' yj w'	<: 2=9;	d=4f
Wj Ā nj' nyr'-	<4Z=	d=5f
Hj ū rwnmy1 'n l ū Ū	9: 2/5	d=6f
ZrT l: : l54) Hj	94Z9	r--'1 nŪ
ZrT l: : l74) Hj	672 9	r--'1 nŪ
ZrT l: :	58Z6	r--'1 nŪ
Q j l Ū' nmlj k' n-	8;	d9; f
Hj' kxwvj w' i kn-	8: Z	d=7f
Wl n q1 -t	84Z=	d=8f
Lj' mwp' j -	75Z	d=9f
Wj Ā l ū Ū	6; Z=	d=6f
Ū' ny' xl n-rwp Āj -'n	66Z;	d=: f
Kn, N3H', N q Ū' n x Ū' m	66Z<	d: 4f
Gj wj y nnu	64Z<	d=: f
T' j w p n y nnu	5<2	d=: f
Fl 'r' j' nmnj' nyr'-, Y B=44 H-	5; Z;	d=5f
Kū Ūj -q	57Z6	d=<f
Hj ū rwnm' j Ā l ū Ū	57Z8	d=6f
Fl 'r' j' nmnj' nyr'-, Y B 944 H-	56Z=8	d=5f
c nxu' n	56Z	d= f
Hj Ū	: Z	d544f
Kū Ūj -q	5Z	d= f

4. CONCLUSION

n v j r w p x j u x o ' q n l 1 ' ' n w ' - ' i n Ū Ā j - ' x j - n - ' q n j m x ' y ' r x w l j y j l r ' Ū x o R G r w Z r T l : : 0 Z r T l : : l 5 4) H j j w m Z r T l : : l 7 4) H j 2 n c ' I R T K - Ā n ' n y ' n y j ' n m j l l x ' m r w p ' x j - r w p u n y x ' - x ū x ' q n ' v j u v n ' q x m - Ā r ' q j j v x m r l j ' r x w 1 - r w p ' j l n j m m ' r p n - x o H j 2 H x v y j ' n m Ā r ' q ' q n Z r T l : : Ā r ' q x 1 ' ' q n v x m r l j ' r x w @ ' q n ' n Ū 1 ' j u y ' x y n ' m - x o ' q n v x m r n m Z r T l : : Ā n ' n n w ' d q n m Ā q u n ' q n r ' y n ' α ' v j w l n - Ā n ' n n w q j w l n m ' x ' n v x ' n R G d x v Ā j - n Ā j ' n 2 n t r w n d - x o R G - x ' y ' r x w x w' x Z r T l : : 0 Z r T l : : l 5 4) H j j w m Z r T l : : l 7 4) H j Ā n ' n n m k Ū ' q n y - n i n x ' - ' j w m - n l x w n k ' m ' v x m m u 2 n - n l x w m v x m m u x n ' n m ' q n k n - ' α ' ' q n n Ū n ' r v n w' j u n j ' j α ' j u - Ū ' n v - - ' i m m m 2 n v n l q j w r - v x o R G - x ' y ' r x w x w' x ' q n - i ' q l n x o R T K - Ā j - r w n - r p j ' n m 1 - r w p l x w j l ' Ā r v n m j 2 X y n l r l j u Ū ' q n r w p x o n Ū n ' r v n w' j u n j ' j ' x ' q n r w ' j y j ' d u n n r 1 - r x w v x m m m m w' r n m ' q ' n n - j p n - r w ' q n - x ' y ' r x w y ' x l n - 2

Q w p v 1 r ' j w m K' n i w n d q y u x ' j w j Ū n - j w m l j d 1 ū ' r x w - ' n ' n j u m ' q j ' Ā ' q n ' j u n - x o ' q n u w n j ' ' n p ' n - r x w l x ' ' n j ' r x w l x n l m w ' , W - α ' ' q n K' n i w n d q v x m m u Ā n ' n p ' n j ' n ' ' q j w ' q x - n α ' ' q n Q w p v 1 r ' v x m m u α ' Z r T l : : 0 Z r T l : : l 5 4) H j j w m Z r T l : : l 7 4) H j 2 F - j ' n - i u 0 ' q n j m x ' y ' r x w x o R G x w' x - r w p u n l v n' j u j w m k r v n' j u c ' I R T K - Ā j - l x w - m m ' n m ' x x l l 1 ' j - v i ū n j Ū ' j m x ' y ' r x w x w j q n ' n x p n w x 1 - - i ' q l n 2

Q w p v 1 r ' v j Ū v 1 v u x j m r w p l j y j l r ' Ū , z_v - Ā j - l x v y j ' n m Ā r ' q x ' q n ' ' n y x ' ' n m j m x ' k n w ' - r w y ' n ' r x 1 - - i m m - 2 n ' j u n - x o ' q n - n y j ' j ' r x w q l ' x ' , W_z r w m j ' n m ' q j ' Ā ' q n j m x ' y ' r x w Ā j - j q ' x i ' j k u n y ' x l n - 2 Z - r w p ' q n

K' n i w n d q u w n j ' v x m m u l x w - j w ' w ' j u n - α ' Z r T l : : 0 Z r T l : : l 5 4) H j 0 j w m Z r T l : : l 7 4) H j Ā n ' n α 1 w m ' x k n v x ' n ' q j w x w n , r x w C 5 - 2 n - n ' j u n - l x w ' v ' q n q ' x 1 ' j k n r ' Ū x o R G j m x ' y ' r x w x w' x - r w p u n l v n' j u j w m k r v n' j u c ' I R T K 2 r - - i n Ū l j w - i p p n - ' q n k r v n' j u l Z r T l : : j - j w j ' j l ' r ' n j m x ' k n w ' x ' n v x ' n n Ū - d x v Ā j - n Ā j ' n 2

AUTHOR INFORMATION

Hx' 'n-yxwmwp F1 'qx'

. J v j r u > w j - n ' j ū v n ' Ū y x - p ' j n l 1 ' ' r w l m j 3 1

T'WHN 

Xqj x k r w] j w p > 44441444615; 951=5: 6

Xqj x v r w Q n > 4444144451945=195<6

REFERENCES

- d5f Fw nmj HFUOI nkjlqn' SF0I xĀw- FŪHx n' Q R nux HFI 2Wlv x'juxov n'qŪ' n w n k u n dōxv l x u ' n m n 1 n w - k Ū j m x ' y ' r x w x w v x w' v x' n u x w' n l ū Ū Q n ' w j u x o H x u x m j w m N' n ' q l n X l m w l n 644=@76 , 5- :8: 1972
- d6f Gqj j l q j ' Ū PL0 Xqj' v j F2 Prwn d - j w m ' q n ' v x n Ū j v d - x o v n ' q Ū' n w n k u n j m x ' y ' r x w x w w n v , F Ū m' j l q ' j r w m j - u j o y x Ā m ' 2 l Ū - j w m y r p v n w - 6449@9, 5- :951=2
- d7f Y1 w 0 Y j w l M0 Ft - i c 2 U k ' n w ' j u 1 - n x o l x x w y j w ' Ā j - n - α ' ' q n ' n v x ' j u x o Wlv j Ū u G j l t G ' n j l ' r ' n n Ū 2 Q 1 ' w j u x o Mj Ū ' m x 1 - R j ' n ' n j u - 644=@: 7 , 5- :5<: 1=2

d8f Fikn' R 0 Qn-rw R X0 Lnl q' r- GK2 R n'q Qnwn ku n> nj wprn'x1 - n'ñh α' wnxwj 'n-2 Q1' wju xo Uhmj' d Xi' pn' Ö6447@<, <- >688192

d9f Mjv nmm GM2 Xynw' 'nj unj° n-> F wnÅ waw l xw' nw'xwj u jwm u Åll x-° j m-x' knw' α' 'nv x° ju xo kj-dl n'ñh d xv jz1 nx1 - -xu 'xw-2 Q1' wju xo Mj Ü' nx1 -R j 'n' tju-644=@: 5, 6- > 971=2

d f Fkmluj qv jw J F0Mnpj ÜhÖWJ uFÜkj ÅÖWJ 2J l mw' 'nv x° ju xo v n'q Qnwn ku n n'ñh d xv jz1 nx1 - v nmj 1 -rw Kp3Xr0H' 3Xr0S r3Xr0j wmc w3Xrjv x' yqx1 -wx° nu j m-x' knw'-2 Q1' wju xo R j 'n' tju- Wñ-nj' l q jwm Ynl qwxup Ö645=@: , - > 97451572

d f Wj g' i uq j R 0 Xi ürv jw T0 Mj-qrv W0 Fqv j m F2 Fm-x' y' xwxov n'q Qnwn ku n xw u Åll x-° j m-x' knw'-> F 'n° mÅ2 Q1' wju xo Mj Ü' nx1 - R j 'n' tju- 6454@; , 5- > 41<42

d f L1 y' j [P0 Xi qj -0 Fur N0 Xjrw [P2 Wñv x° ju xo Wqxnj v rwn G0Kj-° L' nmw0 jwm R n'q Qnwn Gu n d xv] j -n' Åj 'n' Z-rwp Wñm R1 n0 jw Fu v rwn v Nñm -° Ö] j -n2 Nñm -° tju* J wprwnn' rwp Hqnv r-° Ö Wñ-nj' l q 6448@7; , - > 841; 2

d f Wkkrw-xw Y0 R1 R1 u jw L0 R j' l qj w' W0 S p jv U2 Wñv nmj 'xwxonñh-rw n' Cñun n 1 nw' > j l' r' d j u' n° mÅ xw l1 '° nw' ° nj' v nw' ° nl qwxupm- År' q j y' x yx-nm j uñ' wj 'r° n2 Gx' n-x1 l' n Ynl qwxup Ö 6445@; , 7- > 68; 1992

d54f] jwp X0c q1 c2 Hqj' j l' n' r-j 'xw jwm nw' r' xw nw' j u jyyul j 'xwxojw F1 -° j u j w w j 'i' j u üxur' n' α' kj-dl n'ñh 'nv x° ju d xv jz1 nx1 - -xu 'xw2 Q1' wju xo qj Ü' nx1 - v j 'n' tju-644: @7; , 7- > 8: 1962

d55f Gu ^ b0 Fñw M2 F t rwn' d - jwm 'qn' v x n'ñh v d - -i n' Ö xov n'q Qnwn ku n j m-x' y' xw xw Åqñj ^ -qnur-2 I n-j uwj 'xw644: @8, 5- > 69=1; 2

d56f R n-qt x [0R j' t x° -t j QQR rwl qn° j R 0 Wñm rpi n- FJ 2 Fm-x' y' xw xokj-dl n'ñh -xw p' j w ü' j l' r' j 'nml j' kxw jwmw j 'i' j u üxur' n2] j 'n' Wñ-nj' l q 6445@9, 58- > 79; l: 2

d57f] jwp X0c q1 c M2 Hqj' j l' n' r-j 'xw jwmnw' r' xw nw' j u jyyul j 'xwxojw F1 -° j u j w w j 'i' j u üxur' n' α' kj-dl n'ñh 'nv x° ju d xv jz1 nx1 - -xu 'xw2 Q1' wju xo Mj Ü' nx1 - R j 'n' tju-644: @7; , 7- > 8: 1962

d58f] jwp X0 Gñx b0 Hqx1 nk F0c q1 c M2 Wñv x° ju xo n'ñh -d xv jz1 nx1 - -xu 'xw1 -rw Öj-q jwm' nmv i n2] j 'n' Wñ-nj' l q 6449@<, 5- > 6=17<2

d59f Ftkju K2 Fm-x' y' xw xo kj-dl n'ñh -d xv jz1 nx1 - -xu 'xw xw' y1 v d n yx Ånm' 2 Q1' wju xol xuxmjwm rwn' q l n-1 mwl n 6449@<, 6- > 8991<2

d5: f b j p q r T R 0 T f l n n R 0 T l t Å p S] 0 H q j n M P 0 J m j x1 m R 0 P r v Q W h' d i ü' -Ö v' q n r- j w m' q n m- p w x o w n Å v j 'n' t j u 2 S j 'i' n 6447@67; , =85- > 492

d5: f b j p q r T R 0 Q M 0 I j ° r- H 0 W l q j 'm-xw I 0 L' x Ö Y Q X Ö v' q n' d X' j 'n p m-0 X' i l' i' n U j n' w-0 j w m J v n' p r w p U x y n' m- r w 'q n H q n v r-° Ö x o R x m ü' U k' x1 - X x u m-2 F l l x1 w'-x o H q n v d j u W h-nj' l q 5==<@5, <- > 8; 81<82

d5<f G j n w X W 0 W k-xw W 2 N' n' y n w n' j 'r w p w n' > x' m' m n 0 y n' r x m l n w' j w p u n v n w' 2 F w p n Å j w n n H q n v m N' n' w j 'x w j u j m' x w 5==<@; , 55- > 58: 41=82

d5=f K' n Ö L 2 G n m r w p i w' - m m- p w j w m -l j u n l q n v r-° Ö Q1' wju x o X x u m X' j 'n H q n v r-° Ö 6444@96, 5- > 7; 18<2

d64f Pr'j pj Åj X0P xwnx R 2Ki w l' xw j u v d' x y x' n l q n v r-° Ö x o l' Ö-j u r w n v n' j u l x v y u n Q j -n v k u m l x v y x1 w m-2 G u n' r w x o 'q n H q n v d j u X x l m' Ö x o Q y j w 5==<@5 , <- > 5; 7=1972

d65f b j p q r T 0 T f l n n n R 0 P j w j 'Ü m r- R 2 I n- p w x o -x u m- d x v v x u n l i ü' k1 n m r w p k u l t -> p x u n w x y x x' i w' m- α' -x u m -j 'n l q n v r-° Ö Q1' wju xo X x u m X' j 'n H q n v r-° Ö 6444@96, 5- > 162

d66f Ki' i t j Åj M0Hx' m-x° j P J 0 T P n n n R 0 b j p q r T R 2 n l q n v r-° Ö j w m j y y u l j 'x w- x o v n' j u k' p j w l d j v n Å x' t -2 X l m w l n 6457@85; , 58=- > 6748882

d67f c q x1 M I H 0 Q w p W 0 b j p q r T R 2 N' x m l' x w' x v n' j u > x' p j w l d j v n Å x' t -2 F H X U i k u l j 'x w-@4562

d68f R i n u n' Z 0 X l q i k n' ^ R 0 Y n l q K 0 U i n n' M 0 X l q m' u n l F' w m' P 0 U j -° n Q R n' j u x' p j w l d j v n Å x' t -l y' x -y n l 'r° n r w m -° t j u j y y u l j 'x w-2 Q1' wju x o R j 'n' t j u - H q n v r-° Ö 644: @: , ; - > 6: 17: 2

d69f Q l x k Ö R 2 M n j m r w p 'x v j' t n' Å r' q R T K-2 H q n v J w p S n Å -644<@: , 78- > 571: 2

d6: f K i' i t j Åj M 0 P x S 0 L x b G 0 F' j j' w r S 0 H q x r X G 0 H q x r J 0 n' j u Z u' j q p q y x' x-° Ö r w v n' j u k' p j w l d j v n Å x' t -2 X l m w l n 6454@6=, 9=- > 8681<2

d6: f R n u Å j' m F W 0 b j p q r T R 2 R n' j u x' p j w l d j v n Å x' t - Å r' q n Q n y' x w j u Ö q p q l j y j l r' Ö α' -x' j p n x o l j' k x w m x G m j ^ ' x x v 'n v y n' j 'i' n2 Q1' wju x o 'q n F v n' d j w H q n v d j u X x l m' Ö 6449@6; , 95- > 5; ==<1=2

d6<f H j -t n Ö X W 0] x w p l k x Ö F L 0 R j 'Ü p n' F Q I ' j v j' d 'i w w p x o l j' k x w m x G m i y' j t n' t j v n' j u -i k -r' i' x w r w j l x x' m w j 'x w y x u' n' Å r' q l Ö w n d j u y x' n-2 Q1' wju x o 'q n F v n' d j w H q n v d j u X x l m' Ö 644<@74 , 77- > 54< ; 4152

d6=f M j v x w Q X n' n H 0 I n° d Y 0 Q r-nj1 Y 0 R n u j w p n K 0 K' n Ö L 0 n' j u H x v y j' j' r° n -i n' Ö x o q Ö n x p n w -i u m n j m-x' y' x w r w 'q n R N Q 97 , F u 0 H' 0 K n-0 R N Q 18; , [-0 R N Q 1544 , H' -0 j w m R N Q 1545 , H' - v n' j u x' p j w l d j v n Å x' t - j ^ ' x x v 'n v y n' j 'i' n2 Q1' wju x o 'q n F v n' d j w H q n v d j u X x l m' Ö 644=@75, 69- > ; 91; 2

d74f P j' j' j W 0] j u x w P X 2 J n l' x o x y n w v n' j u -r n- x w j m-x' y' x w x o y x ü' j w m w x y x ü' v x u l i u n- r w v n' j u x' p j w l d j v n Å x' t H i l G Y H 2 Q w p v i r' 644<@8, 5: - > 641: 2

d75f G j w l x l G m° j L 0 H j v y x -I R j' 'r w R 0 F u l c j q j w r X 0 K m' x Q 2 J n l' r° n w n- x o v n' j u x' p j w l d j v n Å x' t - α' 'n v x° ju x o 'n d j l' x' Ö x' p j w l u w' l x v y x1 w m y' n-nw' r w u z1 m m a n u-2 K i n u 6455@4, 5- > 5=41; 2

d76f F' -j m G 0 K s n u l p M 0 P x w p -q j i p P T 0 X Å j w p T 0 G x v W 2 F v r w n a w l' x w j u -n m v n' j u x' p j w l d j v n Å x' t - , R T K- j -j m-x' knw'-α' l j' k x w m x G m 2 F m-x' y' x w 644<@8, : - > 991: 62

d77f M j z1 n J 0 Q m Q 0 Q w p N 0 M Å j w p b P 0 H q j w p O X 0 Q p j u Q n' j u F m-x' y' r° n 'n v x° ju x o v n' q Q n x' j w p n d x v j z1 nx1 - -xu 'xw År' q v n' j u k' p j w l d j v n Å x' t -0 y x' x1 - l q' x v n v l k n w ü h w n m l j' k x Q j 'n-2 Q1' wju x o Mj Ü' nx1 -R j 'n' tju-6454@<5, 5- > 9791862

d78f U h' n' -x w L] 0] j p w n' L] 0 G j k x j F 0 R j q u n O X n Å n u Y 0 P j' Å j l t r H Q F v v x w j ° j y x' 'n v x° ju k Ö H i 7 , G Y H- 6 j w m r- l q j' j l' n' r j' x w k Ö R F X S R W 2 n Q1' wju x o U q Ö d j u H q n v r-° Ö H 644=@57, 75- > 57=4: 15; 2

d79f P qj wS F0Q1 wp XM2Fm-x'y'r'n'nv x°juxoknwĭ'qrx l yqnwn 1-rwp yx'x1- lxyyn'lkwnĭwn'dj'kxĭ'ĭ'n ukjmm Ār'q yqx-yqx'1 wp-ĭl j1m2 Ki nu Uxl n-rwp Ynl qwxupĭ6456@44-8=1982

d7: f P qj wS F0Mj-jwc 0Q1 wp XM2Fm-x'y'r'n'nv x°juxo qj ĭ'nx1- v j'ĭ'ĭ'j-1-rwp v n'j'uk'pjwĭl dōjv nĀx't- , R TK-> F 'n°mĀ2 Q1'wju xō Mj ĭ'nx1- R j'ĭ'ĭ'j-6457@881689-88819: 2

d7: f P qj wS F0Qw Q 0Qxwp QM0Q1 wp XM2Wĭv j'tj kun j-m-x'y'r'nyn'α'v jwĭn xoj v n'j'uk'pjwĭl dōjv nĀx't0 °jwjmm v lknwĭwnmĭj'kxĭ'ĭ'n , R NQ18; -0 α' knwĭ'qrx yqnwn2 Hqnv dju Hxv v 1 wĭj'xw- 6455@; , 8- >74: 1<2

d7<f Fqv nm N0Mj-jwc 0P qj wS F0Q1 wp XM2Fm-x'y'r'n mwr'xpnwĭ'xw xō v xnm u a nu- Ār'q yx'x1- v n'j'uk'pjwĭl dōjv nĀx't- , R TK-> J nl' xojl m'r'Ö jwm kj-ĭr'Ö xō R TK-2 Fyyumm Hj'j'ĭ'ĭ- G> J w'r'xw nw'j'6457@6=>671=2

d7=f P qj wS F0Q1 wp XM2QxĀl'nv yn'j'ĭ'ĭ' n'ukj mwp xō H1 / -ynl m- x°n' yx'x1- v n'j'uk'pjwĭl dōjv nĀx't- , R TK- jwm j-m-x'y'r'n m-1 u'ĭ'ĭ'xw Ār'q H1 / 1 ukjmm R TK-2 Q1'wju xō Mj ĭ'nx1- R j'ĭ'ĭ'j-6456@7; 167<>5<4192

d84f Gr I 0 Y'jwĭqnv xw'j'pwn I 0 bjpqr TR 2 R n'j'uk'pjwĭl dōjv nĀx't- Ār'q qp q l j y j l r'Ö jwm -nwl'ĭ'r'Ö α' qj'v a u pj -n-2 Uxl nmmwp- xō 'qn S j'xwju F l j m v Ö x o X l m w l n - 6 4 4 < @ 4 9 , 7 7 - > 5 : 6 7 1 ; 2

d85f Mj v xw Q Q l u n' l M O L q x 1 F 0 T u' m' x Q Y' j' n' ^ F 0 Q' j u n Ö Q H 0 n' j u ĩ R x u n l i j' n w - p q' r w' x' q n j m x' y' r' x w x o M 6 X r w' q n n Ğ k u n R N Q 1 9 7 , H' - j w m ' i p m R N Q 1 8 ; , [- R T K - > r w d j' n m - y n l' x - l x y Ö l x v k r w m x' v x u n l i j' - r v i j' x w - 2 n Q 1' w j u x o U q Ö d j u H q n v r - " Ö H 6 4 5 5 @ 5 9 , 9 - > 6 4 8 ; 1 9 : 2

d86f R x c l ĭ Ö c q x 1 M I Q c q x 1 I I I 0 Q w W I G 0 Q j x U I V 0 M n H I Y 0 n' j u ĩ R n - x y x' x 1 - R n' j' u ĩ T' p j w ĩ K j v n Ā x' t - Ā r' q J Ğ n y' x w j u Ö M p q] x' t r w p H j y j l r' m - α' F m x' y' r' x w M n j' Y' j w - α' v j' x w 2 F n j' w l n m R j' n' j' u - 6 4 5 < @ 4 , 8 - > ; 4 8 7 9 4 2

d87f a 1 n M 0 M i j w p a I X 0 b r w V 0 M i a I 0 c q n w p M I V 0 M i j w p L 0 n' j u ĩ G v n' j u ĩ H j' x w ĩ R n' j' u ĩ T' p j w ĩ K j v n Ā x' t - α' X n u l' ĭ' r' n I Ğ F m x' y' r' x w j w m j n l' ĭ' r' n H' 6 T ; 6 > W ĩ v x° j u ĩ H' Ö j u L' x Ā' q * I n - p w 6 4 6 4 @ 4 , < - > 8 < : 5 1 : 2

d88f F ĭ ĭ j' R W 0 F k m M W 0 U ĩ' j - j v Ö [0 X i w M 0 Y j m R T 0] j w p X 2 F m x' y' r' n' n v x° j u x o j w' k r x' ĩ l - i u x w j v m m k Ö Z r T l : j w m c N K l ; α' Ā j - n Ā j' n' " n j' v n w 2 Q 1' w j u x o H x u x m j w m N' n' q l n X l m w l n 6 4 5 ; @ 4 4 > < < 1 = 9 2

d89f F u F v n' Ö S 0 F k m M W 0] j w p X 0 Q x X 2 J w q j w l r w p F l m l I Ğ F m x' y' r' x w k Ö Z y n j' n m [n' - x w x o Z r T l : 2 Q 1' w j u x o F y y u m m R j' n' j' u - j w m Y n l q w x u p Ö 6 4 6 4 @ , 6 - > 8 1 : 6 2

d8: f F k m M W 0 U q j v L M 0 F w p M I R 0 Y j m R T 0] j w p X 2 F m x' y' r' x w x o H M 8 j w m H T 6 x w c' l v n' j u x' p j w ĩ dōjv nĀx't-2 Q1'wju xō Hxuxm jwm N'n' q l n X l m w l n 6456@: , 5- >64182

d8; f Mj v nmm GM0 Fqv j m FF2 G j' l q j m x' y' r' x w x o v n' q Ğ m n k u n dōxv j z i n x 1 - x u' x w k Ö p j' u l y n n u 0 j w j p' d i u i' j u Ā j - n k r x v j - 2 Q 1' w j u x o M j ĭ' n x 1 - R j' n' j' u - 6 4 4 = @ : 8 , 6 - > ; 4 1 9 2

d8<f Mj v nmm G0 Wj qv jw F2 Wĭv x°j u x o y q n w x u dōxv j z i n x 1 - x u' x w - k Ö j m x' y' r' x w x w' x j l' ĭ' j' n m l j' k x w y' n y j' n m dōxv k r x v j - v j' n' j' u ĩ Q 1' w j u x o M j ĭ' n x 1 - R j' n' j' u - 6 4 4 < @ : 4 , 6 - > ; : 1 < 5 2

d8=f Mx b I X 0 R l P j Ö L 2 U - n i n x l - n l x w m x' m' v x n m u α' - x' y' r' x w y' x l n - n - 2 U x l n - k x l q n v r - " Ö 5 = = @ 8 , 9 - > 9 5 1 : 9 2

d94f] j w p X 0 Q x M 0 a 1 Q F y y u l j' x w x o Ğ x u' n R H R l 6 6 α' k j - ĩ m Ğ' n v x° j u dōxv Ā j - n Ā j' n' 2 Q 1' w j u x o l x u x m j w m r w' n' q l n - ĩ m w l n 6 4 4 : @ - 9 , 5 - > 5 1 < 2

d95f] n k n'] Ö R x' r - Ö H 2 P r w n' d - x o j m x' y' r' x w x w l j' k x w dōxv - x u' x w 2 Q 1' w j u x o ' q n X j w' j' Ö J w p r w n' r w p I ĭ' r - x w 5 = : 7 @ , 6 - > 5 1 : 4 2

d96f L i y' j S 0 P i - q Ā j q j F P 0 H q j x y j m q Ğ Ğ R H 2 F y y u l j' x w x o y x' j' x , X x j w v' ĭ' k n' x - i v - y j w' Ā j - n - α' ' q n' n v x° j u x o v n' q Ğ m n k u n j w m v j i j l q r' n p' n n w n Ğ dōxv j z i n x 1 - x u' x w 2 F' j k r j w Q 1' w j u x o H q n v r - " Ö 6 4 5 : @ X ; 4 ; I X S : 2

d97f Q w X I M 0 Q j w p W X 2 F m x' y' r' x w x o y q n w x u j w m r' - m ĭ' ĭ' j' ĭ' n - dōxv Ā j' n' i - r w p - Ö q n' d' n - r w - j w m u Ā l x - ' w j' i' j u j m x' k n w' > j' n' m Ā 2 Q 1' w j u x o n w' r' x w n w' j u v j w j p n v n w' 6 4 4 = @ 4 , 7 - > 7 7 : 1 8 = 2

d98f Z m m w R Y 0 N j v R F 0 R j q v i m X 0 W t j w ĭ j v j w R 2 F m x' y' r' n' n v x° j u x o v n' q Ğ m n k u n k Ö' n j' Ā j - n 2 Q 1' w j u x o M j ĭ' n x 1 - R j' n' j' u - 6 4 4 = @ : 8 , 5 - > 7 1 : 4 2

d99f Q l p n' p' n w X 2 c i' ' q n x' m m' - x p n w j w w' n w j m x' y' r' x w p n u - n' - x n 0 P i w p u j X' n w - t j [n' n w - t j y - j t j m v m w - 2 M j w m r w j' 2 6 8 , 8 - 0 5 1 7 = 2 R d' x l q n v d j u Q 1' w j u j w' r' x w X l r Y n l q w x u O H x u x m N' n' q l n X l r O H x u x m N' n' q l n X l r J w' r' x w X l r Y n l q w x u W' X l V i v U ĩ' 0 F v n' d j w] j' n'] x' t - F - x l j' x w H q n v J w p Ö 5 < = < 2

d9: f Mx b X 0 R l P j Ö L 2 U - n i n x l - n l x w m x' m' v x n m u α' - x' y' r' x w y' x l n - n - 2 U x l n - G x l q n v r - " Ö 5 = = @ 8 , 9 - > 9 5 1 : 9 2

d9; f I n v' r' M 0 Y x y F 0 G j t - n I 0 t X 2 I Ğ j m x' y' r' x w k n q j' r x' x o Q j l Ğ m n d j k n' - 2 Q 1' w j u x o M j ĭ' n x 1 - R j' n' j' u - 6 4 4 < @ 7 , 5 1 6 - > 7 < = 1 = 8 2

d9<f W j w j y q j w r X 0 H q j' r' j' R 0 G n v w n' Ö 0 W j' j w j y q j w r [2 F w j m x' y' r' x w j w m' q n' v x n Ğ j v d - ĭ' n Ö x o ĭ l n Ğ r w p x w l x x w y' n' n j' n m Ā r' q l q r' x - j w 2 I Ğ - j w m y p v n w' - 6 4 4 ; @ 6 , 5 - > < 1 = : 2

d9=f R x i - j' r' L O P q x - j' r' W 2 n' n v x° j u x o l j' x w ĩ m Ğ - dōxv j z i n x 1 - x u' x w - k Ö j m x' y' r' x w x w' x y r - j l q x q i u Ā j - n 2 H q n v d j u j w p r w n' r w p W ĩ - n j' l q j w m l n - p w 6 4 5 5 @ = , 5 4 - > 6 5 < 6 1 = 2

d: 4f S j v j - r' j Ğ v H 0 X i v r' q' j X 2 W ĩ v x° j u x o m' n l' ^ n m 5 6 G j w m v n' q Ğ m n k u n dōxv Ā j' n' k Ö j m x' y' r' x w x w' x K n , N N 3 H' , N N q Ğ ĩ x Ğ m 0 j w r w m - " ĭ' j u - x u m Ā j - n 2 Q 1' w j u x o J w' r' x w n w' j u R j w j p n v n w' 6 4 4 9 @ 8 , 7 - > 6 4 ; 1 5 9 2

d: 5f L i y' j L 0 U j - j m L 0 U j w j Ö P 0 X r w p q [2 W ĩ v x° j u x o l q' x v n n Ğ dōxv j z i n x 1 - x u' x w - k Ö Ö j - q 2] j' n' 0 F r' Ö j w m X x u X u u' x w 5 = < < @ , 5 1 6 - > 5 7 1 6 8 2

d: 6f Mj v nmm GM0 Fqv j m F Q Q Ğ' r P S F 2 F m x' y' r' x w x o k j - ĩ m Ğ , v n' q Ğ m n k u n - x w' x j l' ĭ' j' n m l j' k x w y' n y j' n m dōxv ' j j w - Ā m - 2 I Ğ - j w m U p v n w' - 6 4 4 ; @ 9 , 5 - > 8 7 1 = 2

d: 7f Mj v nmm GM0 I r w F Y R 0 F q v j m F Q F m x' y' r' x w x o v n' q Ğ m n k u n x w' x k j v k x x l k j - n m j l' ĭ' j' n m l j' k x w >

- P rwn'd -j wmnz1 ruk' n v -'1 nm-2Q1' wj uxomj ũ' nx1 - Rj 'n'ij u-644; @85, 7- <5=1692
- d; 8f Mj u PW0 J jpn'xw QH0 Fl' r'x- F0 [n'v ni unw Y2 Uk'nljwm -xumlnr 1-ixw trwn'd- rw Gmknm jmx'y'rxw 1wm' l xw-j'w'lyj n'w l xwn'r'xw-2 Nm -'ij u * J wprwnn' rwp Hqnv r-' Ö K wnj v nw'j u-5=: : @, 6- >561672
- d; 9f L1 y'j L X0U j -j mL0Uj wnj ÖPP0Xwpq [S 2Wlv x'j u xolq'xv n nÖ d'xv jz1 nx1 - -xu 'rxw- kÖ Öj -q2] j 'n' OFr'Öj wmxruUku 'rxw5=<<@; , 5- >571682
- d; : f P1 v j' P [0Wj v j v 1' 'qr [0Xr'j wn-j wX2R xmuwv 'qn v nlqj wv- rw'xü nmm' rwp 'qn -x'y'rxw xov n'qÖmw ku n xw'x Öj -q2 Q1' wju xolxum jwm rwn'qj l n -l mwl n 6449<@8, 5- >581652
- d; ; f Fkm MW0 Fwp MR 0] jwp X2J nl ^- xoj v v xwn v qÖmxGm xw 'qn -'1 l'1' n jwm pj- jmx'y'rxw xowjwx-rÜm c' IR TK- , ZrT l: : -2 S jwx-lj un 6456@ , 54- >74<=1=82
- d; <f Wnj c M0Fkm MW0Xi wM0] jwp X2Gru w' rxwj uÜm R n'ju T'pjw K'jv nÄx't-0 ZrT l: : IS T 6IS , S B IS M60 1, TM-60 1, HT TM-6-0 α' J wqj wlm Fmx'y'rxwjwmXunl 'r'r'ÖxoHT 6 jwmS 62Q1' wjuxo Hqnv d'ju* J wprwnn' rwp I j'j 6459@4, ; - >5961: 52
- d; =f Fu Mj Öj' R 0 Fkm MW0 Xi wmn'ijwm G0] jwp X2 R1 ürv n'ju x'pjw d'jv nÄx't- j- m1p l j' m' -> j l nl uxwjl j -j m1p l jwmnj 'n2I '1 p I n-I n' nu n' 645<@7>671792
- d; 4f Fkm MW0Yj wM0Fwp MIR 0Yj m R T 0G l t uÖHJ 0] jwp X2S jwx-rÜh c' lv n'jux'pjw d'jv nÄx't , ZrT l : : - α' qÖmxpnwjwml j'kxwmxGm -'x'jpn2Hqnv d'ju J wprwnn' rwp Q1' wju6456@< ; >591642
- d; 5f Fkm MW0 Xqjwp Ö Fwp MIR 0] jwp X2 Fv rxw la w' rxwj uÜm c' IR TK wjxj' 'd un- α' jmx'y'rxw xohT 6 jwmHM82N'n'w'j'rxwj uQ1' wjuxo Xv j' 'jwmS jwx R j 'n'ij u-6457@, 5- > 61<62
- d; 6f I r R j' rwx F0 R nwm1' r K2 n'v xnmj v d- xolxv yuG' rxw xomv n'qÖ n-n' - xol'n n10 r-x10 jwm yq'qj ul jlm- Är'q l jwm 1l ÖxmC' r-2 Fyyum -ynl "x-lxyÖ6448@< ; - >671742
- d; 7f I q1 v j uS W0Xwpq R UOFwm' -xwF0Pman' ÖPv MQ R xunl i j' N'n'j l' rxw- xoj H1 IGj -nmR n'j tE T'pjw K'jv nÄx't Är'q j Hxv wnmN mj Üun v IGj -nmNwL Qz1 m>F Hxv krwm1 n w-r'ÖK1 w' rxwj u nx' Öjwm J Gyn'v nw'ju [ik'j' rxwj u Xynl "x-lxyÖ X'1 mÖ n Q1' wju xolq'Ö d'ju Hqnv r-' Ö H 645: @64, : - >76=91 7482
- d; 8f Hxj 'n- QN'n'y' n'j' rxwxorwój' nm-ynl "j0j y'j l' d'ju jyy'xjlq2 J wL Öxynmj xolwjuÖ d'ju lqnv r-' Ö 6444@6>54<5917; 2
- d; 9f F'xt n Z0 Fkm t j'v F0 T p1 k1 wt j W2 Kx1' m' l "jw-α' v r wój' nm1qj' j l' n' rÜj' rxw xotjxuw0 p'jw'n0 knw'xw'n jwmkj' r'n2FYGZ Q1' wjuxoJ w'r'xw nw'ju Ynl qwxupÖ6457@, 5- >861972
- d; : f Mx b0R1 Pj ÖL2 n trwn'd -xox'y'rxwxokj -d nÖ- d'xv jz1 nx1 - -xu 'rxw kÖ -yqj pwa v v x- ynj '2 n Hj wj m j w Q1' wju xolq'nv d'ju J wprwnn' rwp 5=<<@; , 8- >661; 2
- d; ; f G u ^ b0 FÖnw M2 F trwn'd - jwm 'qn'v xnmj v d- -'1 nÖ xov n'qÖmw ku n jmx'y'rxw xw Äqnj ^ -qnw-2 I n-j urw 'rxw644: @=8, 517- >69=1; 2

- d; <f Xnw'qru P1 v j' U0 Xnw'qj v j'j r H0 I1 i'pjm'r F2 Fmx'y'rxw trwn'd-0 v nlqj wv-0 r-x'qn'v 0 jwm 'qn'v xnmj v d j wjuÖr- xolxyyn' rxw- xw'x 'qn -'1 qj l n v xnr nm j p' d1 ü' j u Äj -'n2 J w'r'xw nw'ju Uxp'n-* Xi -j r w j k u j w n' p Ö6458@7, 5- >6<17; 2
- d; =f Fr Q Qj wp Q K j -' nv x'j u xolx'pjw d' nÖ- d'xv jz1 nx1 - -xu 'rxw- kÖ FH3n'x-yrwu l xv yx-r'n2 I n-j urw 'rxw6454@, 6, 5- >5781842
- d<4f Fr Qc qj wp H0Hqnv c 2Wlv x'j u xov n'qÖmw ku n d'xv jz1 nx1 - -xu 'rxw kÖj -xüx'qn'v j ul-Öv'qn-rÜm p'jyqnv3v jpw'n'r'n l xv yx-r'n2 Q1' wjuxomj ũ' nx1 - Rj 'n'ij u-6455@=6, 7- >59591682
- d<5f Fkm MW0Wnj c M0Q b0R xqj v v nmMF0] jwp b0] jwp X0n'j uGxx-rwp HT 6 jmx'y'rxwjwm-nunl 'r'r'Ö rw v n'j tE x'pjw d'jv nÄx't- xol R NQ1=, Fu 'ij -nl xwmv n'juHj lxx'mw'j'rxw2WXH Fnfj w l n-6464@4 , 58- >5741=2
- d<6f I x j w R 0 Ümv r' b0Futj w R 2Fmx'y'rxw trwn'd - jwm v nlqj wv- xolj'rxw d' v n'qÖ 'rxw' jwm v n'qÖmw ku n nÖ-xw'x -nyxur'n2I Ö-jwmUpv nw'-644; @9, 7- >451572
- d<7f c j kxxw X0 Fkm MW0 b j x c 0 L1 kwn' W0] jwp X0 G'rdj w R 2Wlv x'j u xolxw'x n'qÖmw pÜxu d'xv Äj -'nÄj 'n' kÖ 1 -rwp c' lv n'ju x'pjw d'jv nÄx't-2 Q1' wju xolxum jwm N'n'qj l n Xl mwl n 645<@67> ; 91<92
- d<8f Ö G0 Xqj x K0 M1 L0 c qnwv X0 c qj wp V0 a1 c 2 Fmx'y'rxw xov n'qÖ 'n' l k1 'Ö n'qn' , R YGj - d'xv jz1 nx1 - -xu 'rxw kÖ yx'x1 - yx'Ö n' d jmx'knw'-2 Q1' wjuxomj ũ' nx1 - Rj 'n'ij u-644=@; 5, 5- >51; 2
- d<9f L1 y'j S0 P1 -qÄj qj FP0 Hqj xyjmqj Öj R 2 Fmx'y'rxw -'1 nm- xolj'rxw d' nÖ- xw'x F-qxtj , Xj'j l j -x l j - u j o yxÄm'2 Q1' wju xolx'qn Yj rÄj w N-r'1 'n xolq'nv d'juJ wprwnn' -6456@7, 8- >481572
- d<: f] nwp H1M0 Qw b1Y0 YÜwp Y1] 2 Wlv x'j u xolx v n'qÖmw ku n d'xv jz1 nx1 - -xu 'rxw kÖj mx'y'rxw xw'x yrwjyyun u j o yxÄm'2 Q1' wju xolx Mj ũ' nx1 - Rj 'n'ij u-644=@; 4, 5- >85; 1682
- d<; f Mx b1X0 R1 Pj ÖL2 Xx'y'rxw xolnÖ d'xv jz1 nx1 - -xu 'rxw kÖ ynj '2 Hqnv d'ju nwpwnn' rwp sx1' wju 5=<<@4, 6- >591682
- d<<f Uxwv -j v r [0 [t'j v X0 X'r'j -j'j XS 2 L1 j'j , U-mv p1j s'j - u j o yxÄm' >S x'nuj mx'knw' α' 'nv x'j u xolx v n'qÖmw ku n d'xv jz1 nx1 - -xu 'rxw-2 Q1' wjuxomj ũ' nx1 - Rj 'n'ij u-644<@96, 5- >6; : 1<: 2
- d<=f Tu'r'j QX0 K'j wj FX0 Fün- YR0 Wklj Xl 2 J'j u j' rxw xolw'nj 'nm l x nn q1 t- j- yx'nw'j u kx-x'knw'-α' "nj 'v nw'xonÖ l xw'j v wj 'nmÄj 'n'-2 Q1' wjuxomj ũ' nx1 - Rj 'n'ij u-644<@99, 7- >94; 1562
- d=4f T'n'x R0Vklj nj K0Hj d'x QK0Lj l' j Öj FNR x' wF2 Prwn'd jwmnz1 ruk' n v v xmuwv xolx'qn v n'qÖmw ku n 'nv x'j u d'xv -xu 'rxw kÖ jmx'knw' v j 'n'ij u- y'xm l nm d'xv -nÄjpn -u n p n-2 Gxl qnv d'ju J wprwnn' rwp Q1' wju6447@9, 5- >91= <2
- d=5f Gj wj ^ K0FuF-qnq X0FuR j t qj nv nq QJ'j u j' rxw xolx'qn 1-n xolj'Ä jwm j l' r'j 'nm nj 'n yr'- j- yx'nw'j u jmx'knw'- α' nÖ l xw'j rwp Äj 'n'-2 Uxl n- Gxl qnv r-' Ö6447@=, 6- >5=716462
- d=6f Lqx-q I 0 Gqj j l qj' Ö P2 Wlv x'j u xolx' d'xv jz1 nx1 - v nm v kÖ -x'y'rxw xw wj '1 j ul j Öj -'1 nÖ

Är'q v n'qÖwn ku n2 \$ I N S C T Z W S F Q T K
J S [N T S R J S Y F Q U W T Y J H Y N T S 6445@5
, 54- >471542
d=7f b j x b 0 a 1 K 0 H q n w R 0 a 1 c 0 c q i c 2 F m x ' y ' r x w
k n q j ° r x ' x o v n ' q Ö w n k u n x w l j ' k x w w j w x ' i k n - 2
G x ' n - x 1 ' l n Y n l q w x u p Ö 6454@45, = >4841: 2
d=8f [j m ° n j w [0 P 1 v j ' P [2 J z 1 n u k ' n v 0 t r w n ' d - 0
v n l q j w r - v 0 j w m y ' x l n - n m - r p w α ' ' q n - x ' y ' r x w x o
v n ' q Ö w n k u n x w x ' d n q i - t 2 Q 1 ' w j u x o H x u x m j w m
N w ' n ' g l n X l m w l n 6449@<: , 5- >415442
d=9f P 1 v j ' P [0 U k ' t x n r P 2 R j - ' j w - a i 0 t r w n ' d - j w m
n z 1 n u k ' n v - i n m - α ' ' q n k r x - x ' y ' r x w x o v n ' q Ö w n
k u n i - r p w U j - y j u v w x j ' i v 2 Q 1 ' w j u x o M j Ü j ' n x 1 -
R j ' n ' i j u - 644; @8: , 5- >5816: 2
d=: f G j w n ' s n n X 0 I j - ' m j ' R L 2 Z - n x o s ' n y ' x l n - r p w Ä j - ' n -
α ' ' n j ' v n w ' x o Ä j - ' n Ä j ' n ' l x w j v r w j ' n m Ä r ' q n Ö j w m
x ' q n ' x ' p j w d - 2 G x ' n - x 1 ' l n Y n l q w x u p Ö 6449@:
, 5; - >5=5=16<2

d=: f F w w j m ' j r L 0 Q j w p W X 0 Q n n I Q Z - n x o
l n u u x - n l k j - n m Ä j - ' n - α ' j m x ' y ' r x w x o m Ö - ö x v
j z 1 n x 1 - - x u ' r x w - 2 Q 1 ' w j u x o M j Ü j ' n x 1 - R j ' n ' i j u -
6446@6, 7- >6: 71; 82
d=<f] j w p X 0 G x Ö x x b 0 H q x 1 n k F 2 F l x v y j ' j ' r ' n - i n Ö x o
n Ö ' n v x ° j u i - r p w Ö j - q ' n j ' n m k Ö m r ' n n w ' v n ' q x m - 2
H q n v x - y q n ' n 6449@4, 54- >58451; 2
d=f] x x ü j ' m H I 0 X ' x w p Ö J ' j - v i - H W 2 J ° j u j ' r x w x o ' q n
i - n x o v x m r n m l x j u j - q j - j y x ' n w ' i j u - x ' k n w ' α '
x ' p j w d Ä j - ' n - ' n j v - 2 F y y u n m L n x l q n v r - ' Ö 6446@;
, <- >59=1: 82
d544f L ' - n - F 0 P j ' j l j X 0 I x j ' 0 G j Ö j t W 0 F t Ö m Ü R 0
b j u w R 2 I n ' n v r w j ' r x w x o j m x ' y ' r ' n y ' x y n ' m - x o
l ü Ö Ä j ' n ' - Ö ' n v > v n ' q Ö w n k u n - x ' y ' r x w 2 Q 1 ' w j u x o
H x u x m j w m N w ' n ' g l n X l m w l n 6448@: =, 6- >54182



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