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Technology Collaboration Programme by iea

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Enhanced Oil Recovery

Development and implementation of bio-nanotracers obtained from agro-industrial waste for application in improved recovery processes in the hydrocarbon industry

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Enhanced Oil Recovery

Info

Bio

Convergence

Cogno

Nano

Nanotechnology *is a crucial player in the fourth industrial revolution as part of convergent technologies, alongside* ***biotechnology, information technology, and cognitive science*** *that will lead humanity once more to break barriers and address challenges, reducing the gap of what we can do and the way to do it responsibly.*

Energy Fuels 2021, 35, 23, 19266–19287

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Energy Fuels 2021, 35, 23, 19266–19287

What about tracers?

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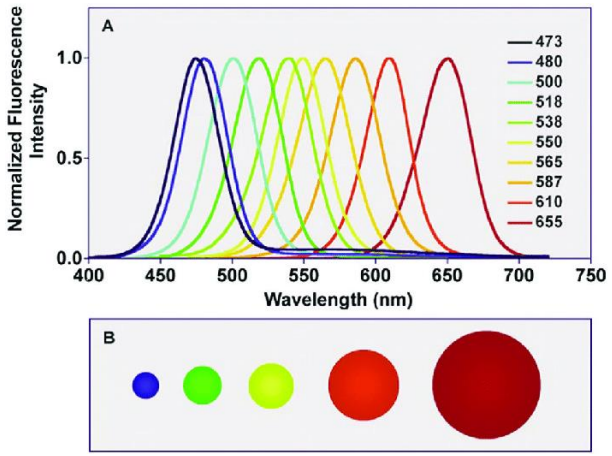
Conventional tracers

- Non cost-effective detection
- No real time detection
- Could be toxic
- Non environmentally friendly

Quantum dots



https://www.bu.edu/eng/2017/06/13/what-are-quantum-dots/

Girma, W. M., Fahmi, M. Z., Permadi, A., Abate, M. A., & Chang, J. Y. (2017). Synthetic strategies and biomedical applications of I–III–VI ternary quantum dots. Journal of Materials Chemistry B, 5(31), 6193-6216.

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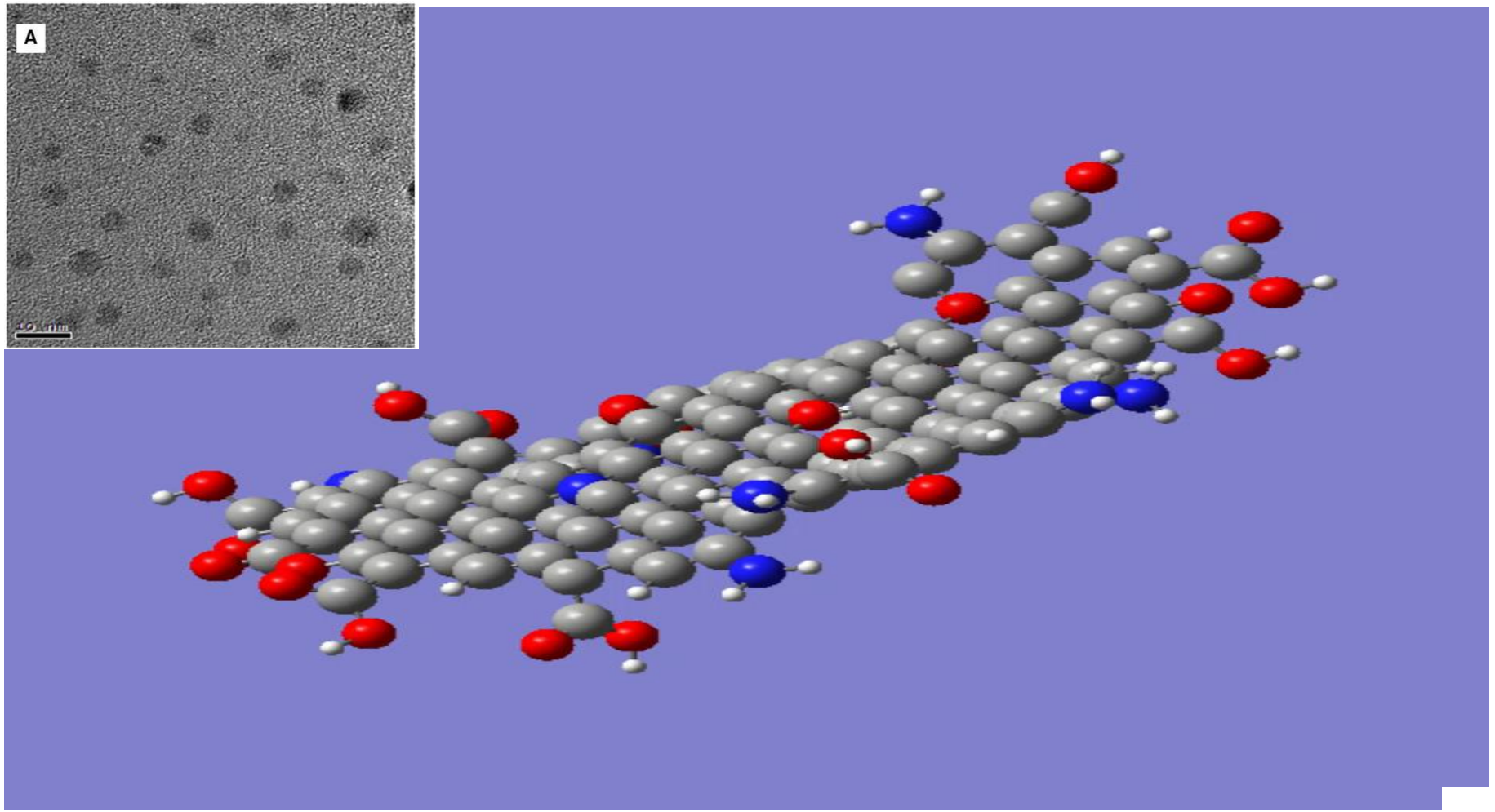
Quantum dots



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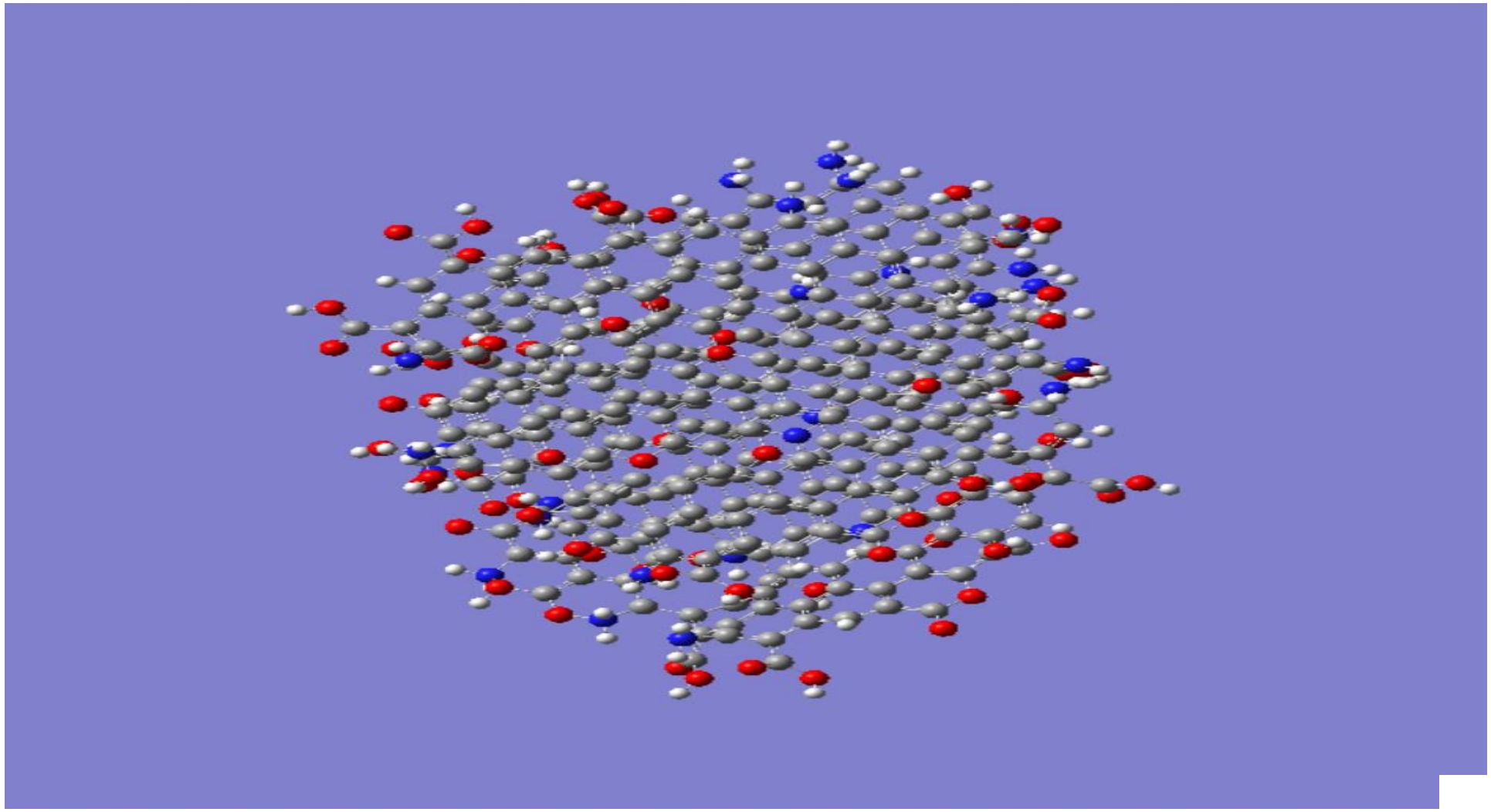
Quantum dots



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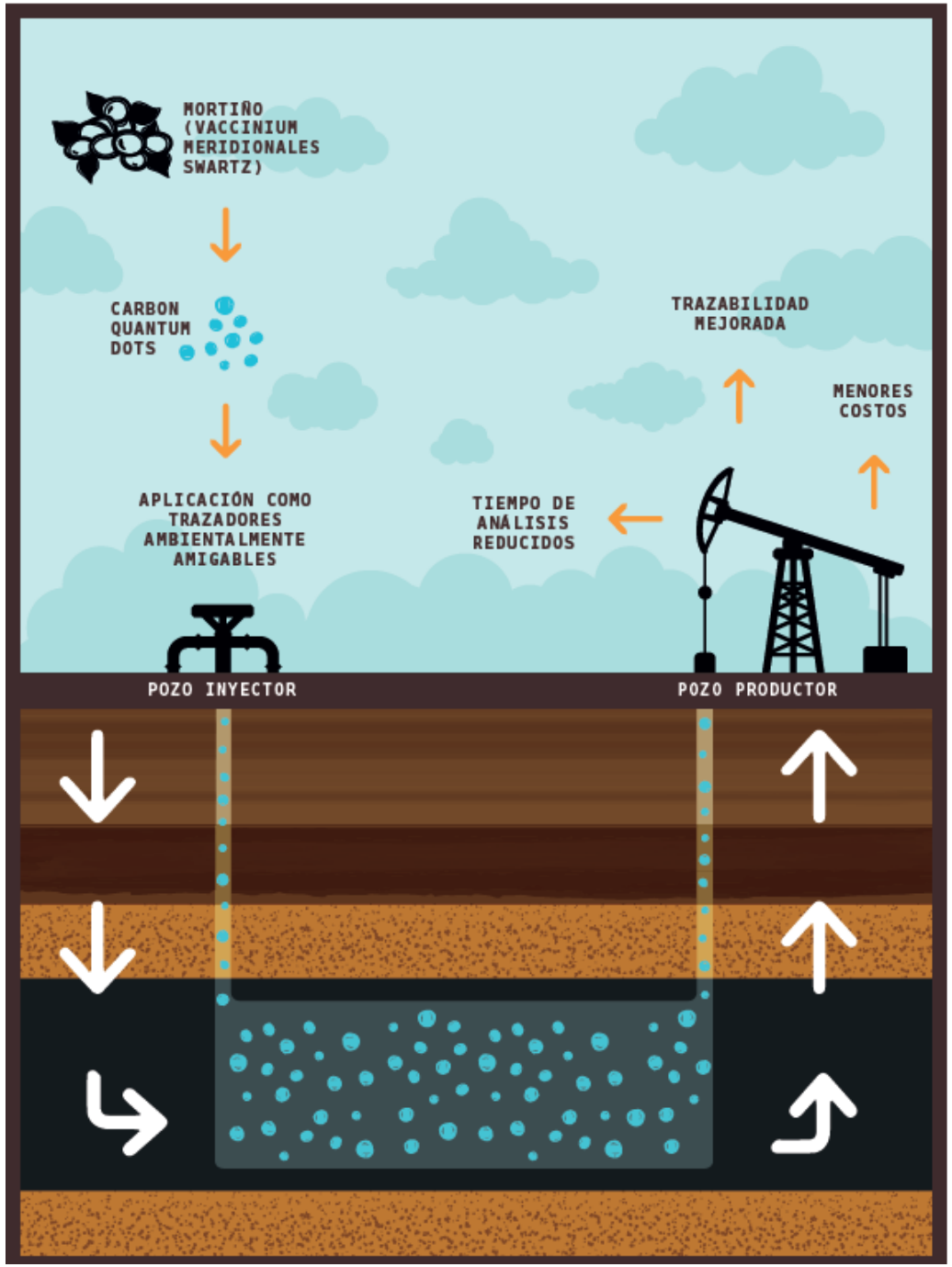

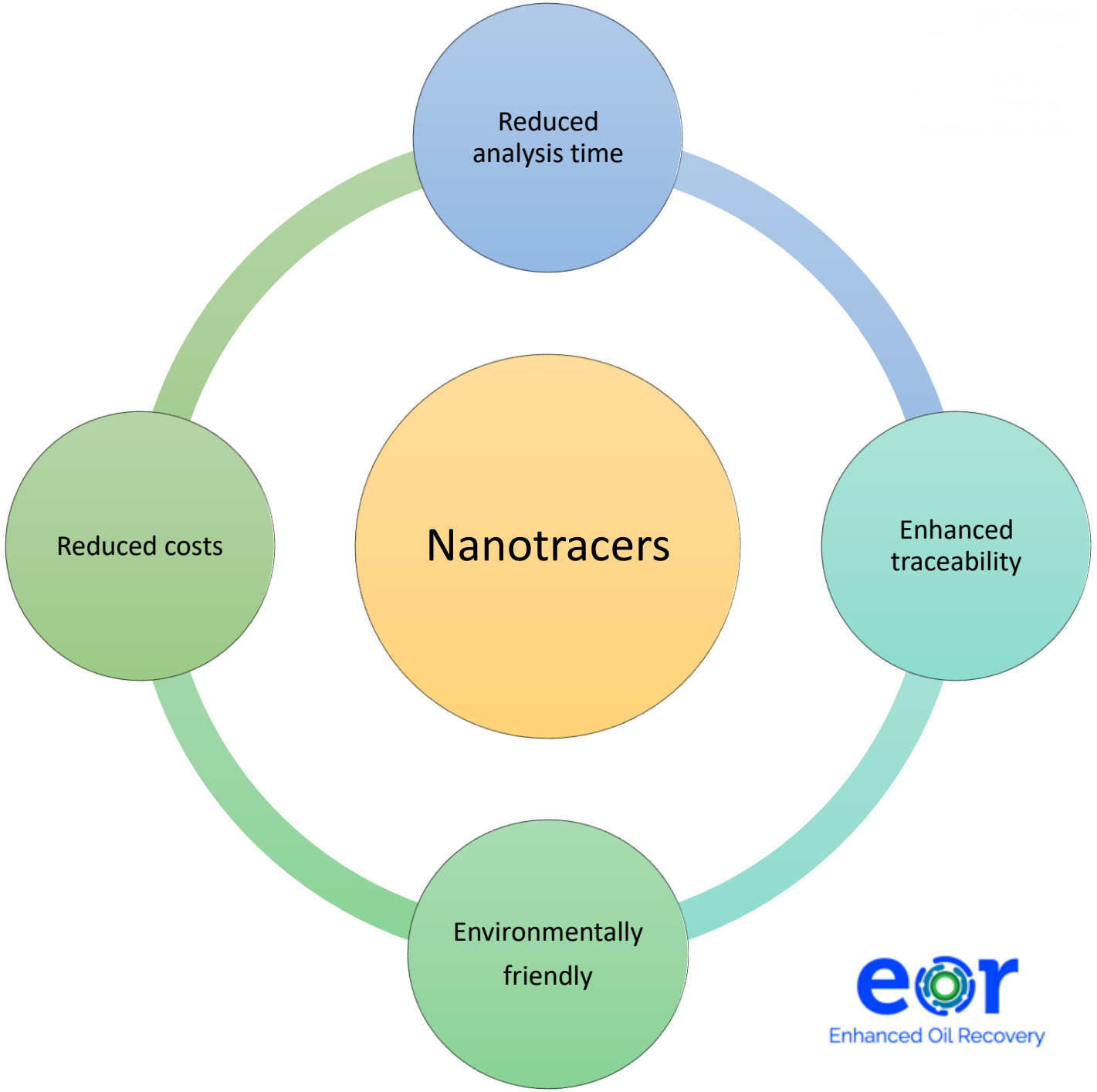

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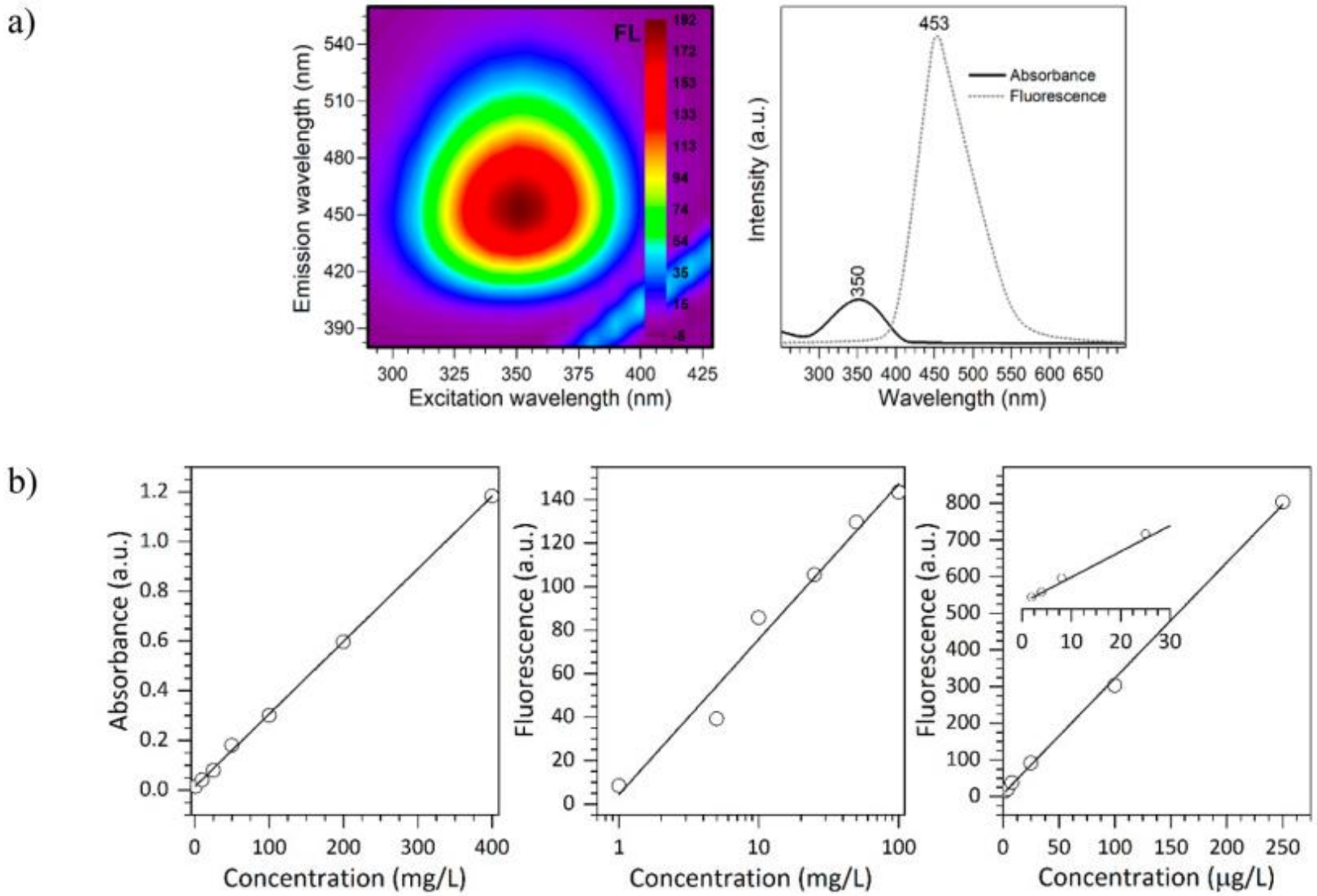

Figure 2. (a) 3D fluorescence spectrum as a function of the excitation wavelength (left), and the absorption and fluorescence spectra at a 350 nm excitation wavelength (right). (b) (left) Absorbance calibration curve, (middle) fluorescence calibration curve at 1% of detector attenuance, and (right) fluorescence calibration curve without attenuance. The fluorescence response was measured at a maximum of 450 nm at a maximum excitation wavelength of 353 nm.

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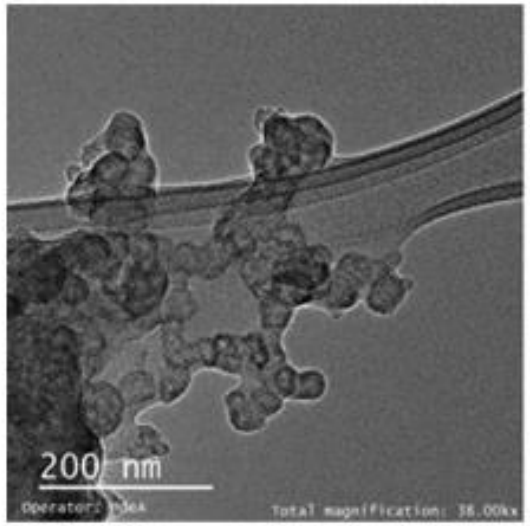

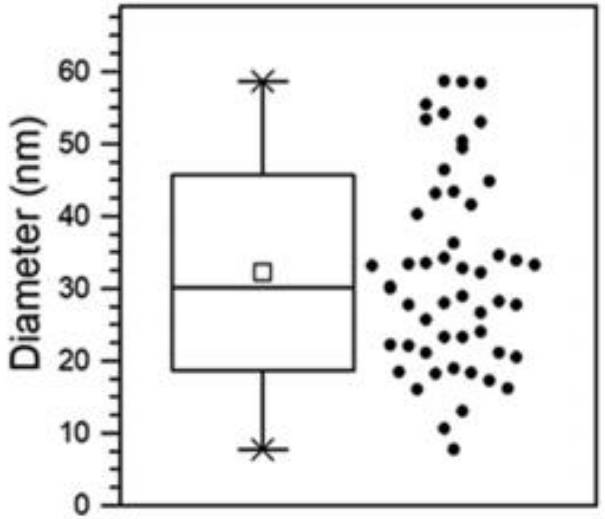

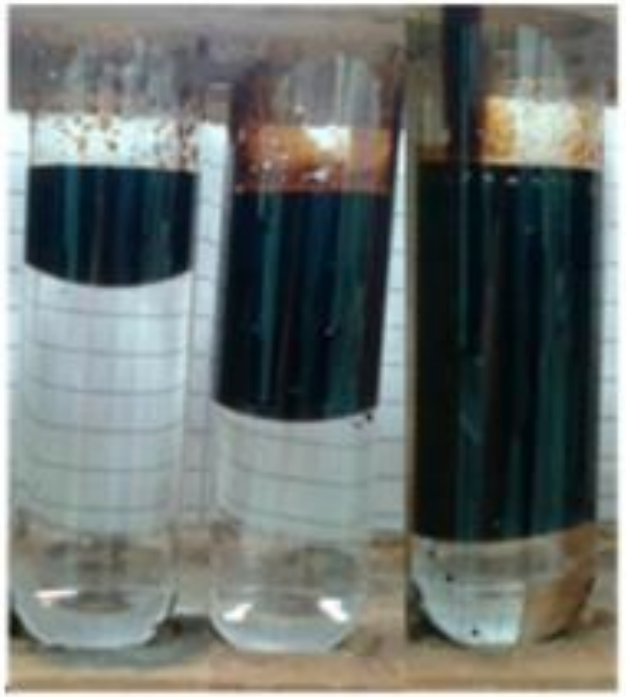

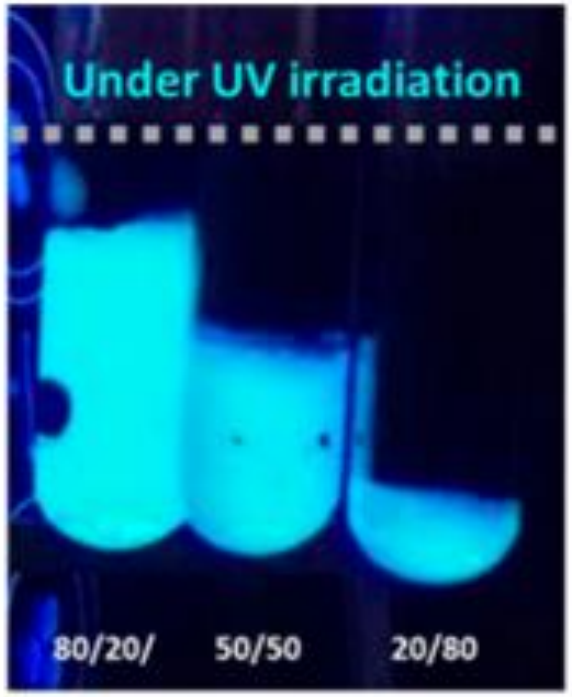

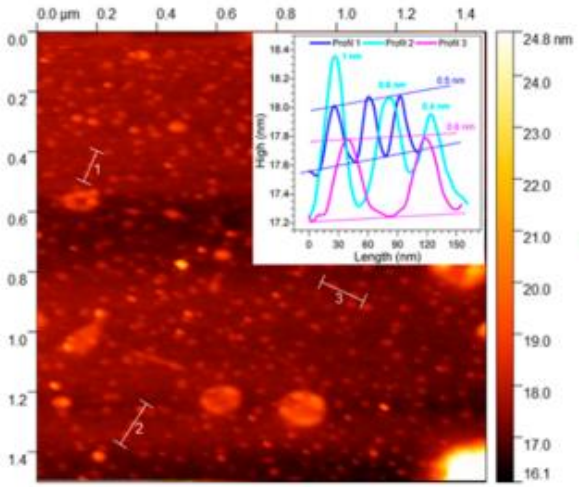

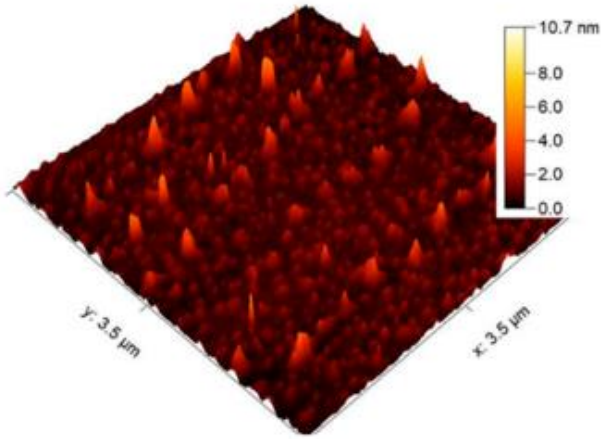

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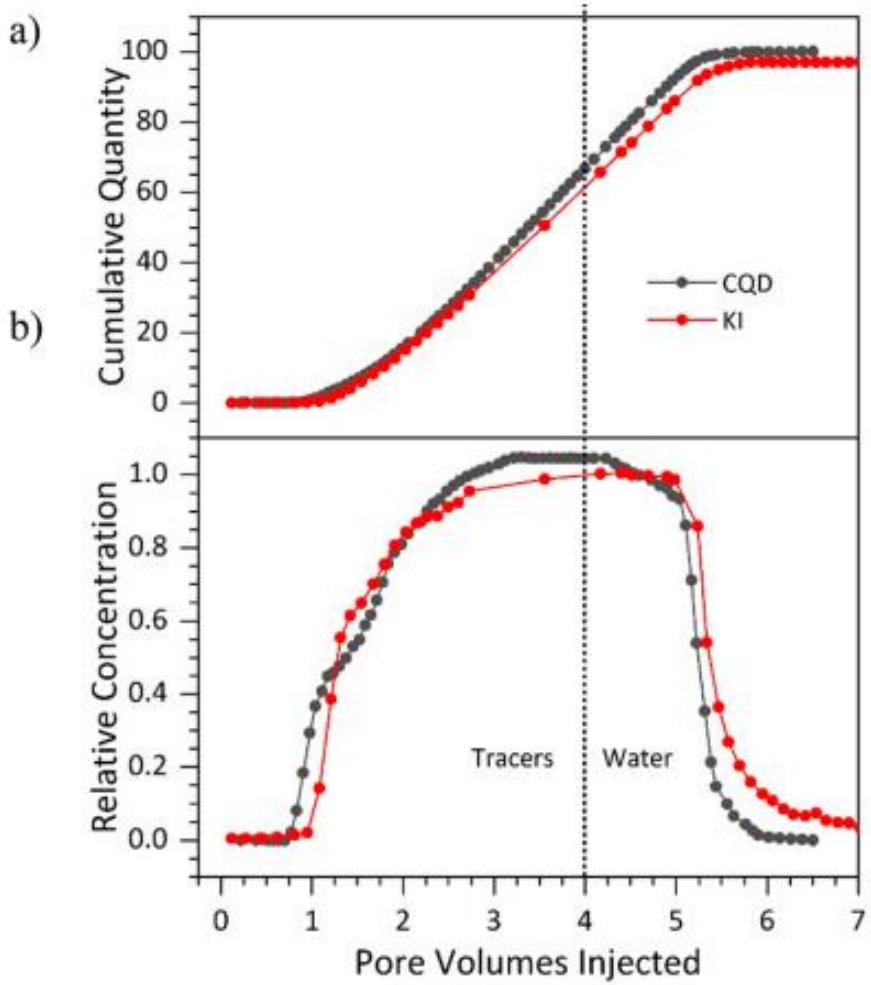

Figure 10. (a) Retention profile, and (b) cumulative CQD production in a micromodel using synthetic sea sand and a 100 mg L^{-1} concentration of CQDs. Profiles are compared with the retention of KI to secure similar results in traceability processes.

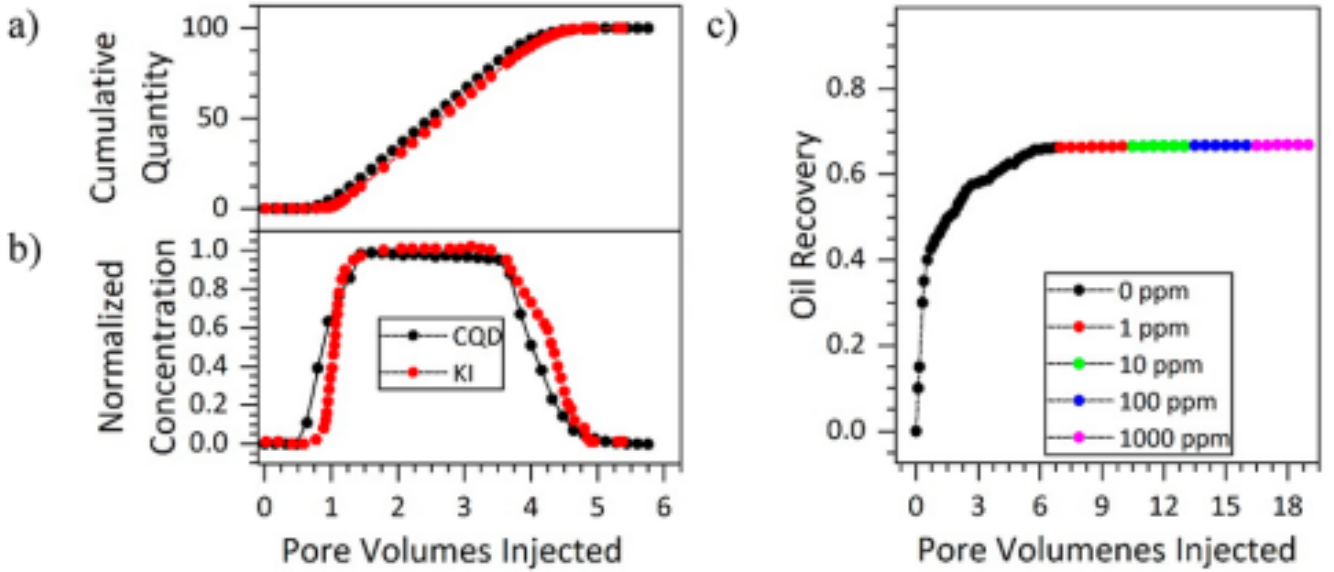

Figure 11. Displacement results for CQDs in a Colombian field core at field pressure and temperature conditions: (a) retention profile, (b) cumulative CQD production, and (c) oil recovery results. A 100 mg L^{-1} CQDs dispersion in injection brine was used. Profiles are compared with the retention of KI to secure similar results in traceability processes.

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Enhanced Oil Recovery

Injection

Production

Field trial

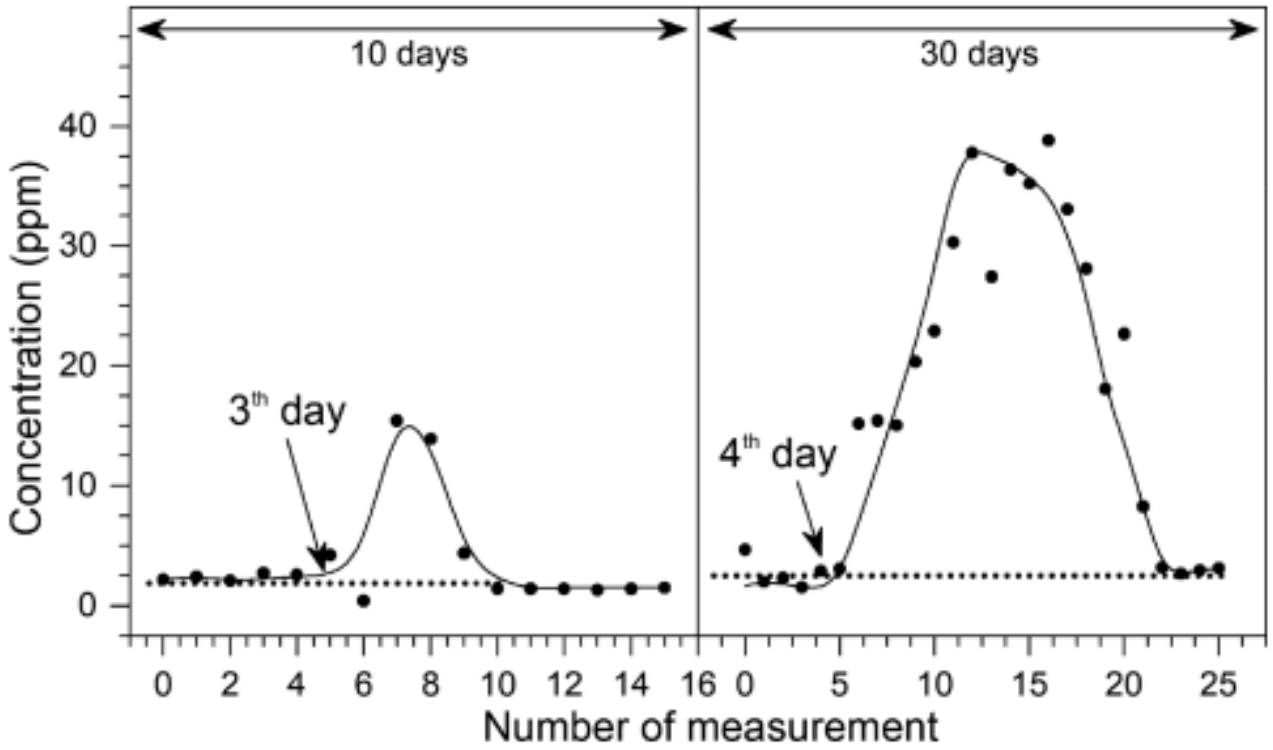

Figure 12. CQDs tracer test in a Colombian field during a conventional waterflooding operation. The concentration of the CQDs at the producer wells is a function of time. The CQDs were injected as a concentrated (500 000 mg L^{-1}) batch.

The expansion of this technology covers > 10 fields by 2022

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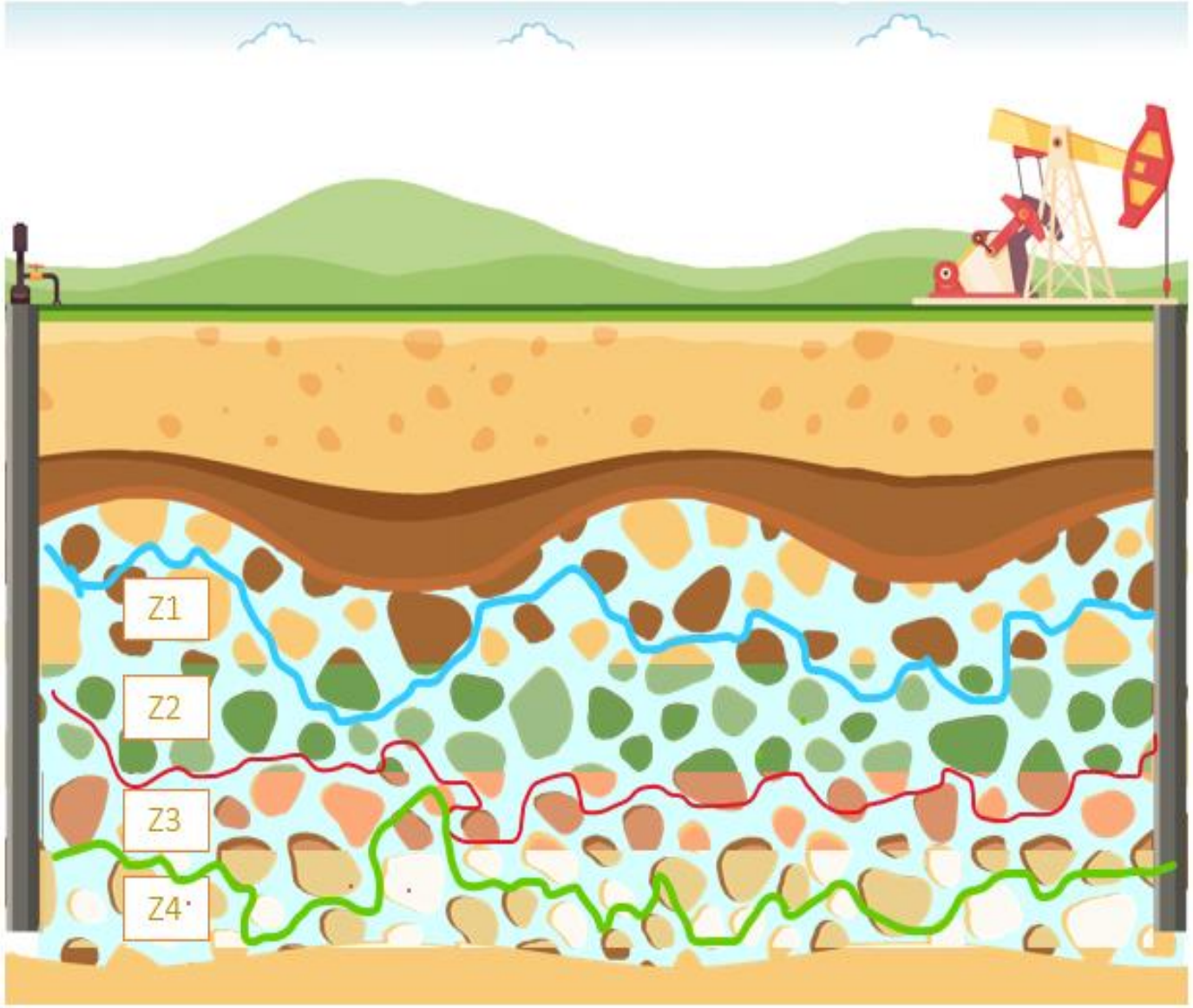
Enhanced Oil Recovery

Multi tracer injection



- There is the need of using several tracers for different zones of interest.
- Another need is related to several injection Wells related to a single producer.

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Multi tracer injection

Methodology

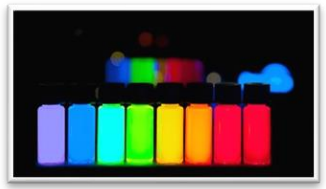
Novel synthesis

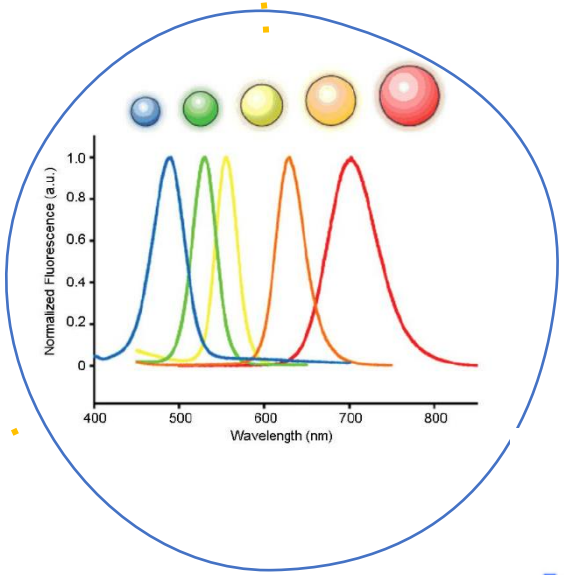
- ✓ Sustainable C sources

- ✓ Met. carbonizing
  - Microwave
  - Solvothermal

Surface modification

- N sources (Amine 1, 2 y 3)
- Heteroatoms (O, P, S)
- Transition metals
- Surface oxidation





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Enhanced Oil Recovery

Multi tracer injection

Different "colors"

- Different sources of C and N
- Different sizes

Agro waste

Coffee pulp: 43,6% fruit- 2'400,000 ton/year .

Rice husk: 512.850 ton in 2019 – bad disposal

Cane bagasse; 6'422,624 ton/year, opportunity

Fruit peel: Banana, Orange, Mango y Pineapple,

Bio-nanotracers

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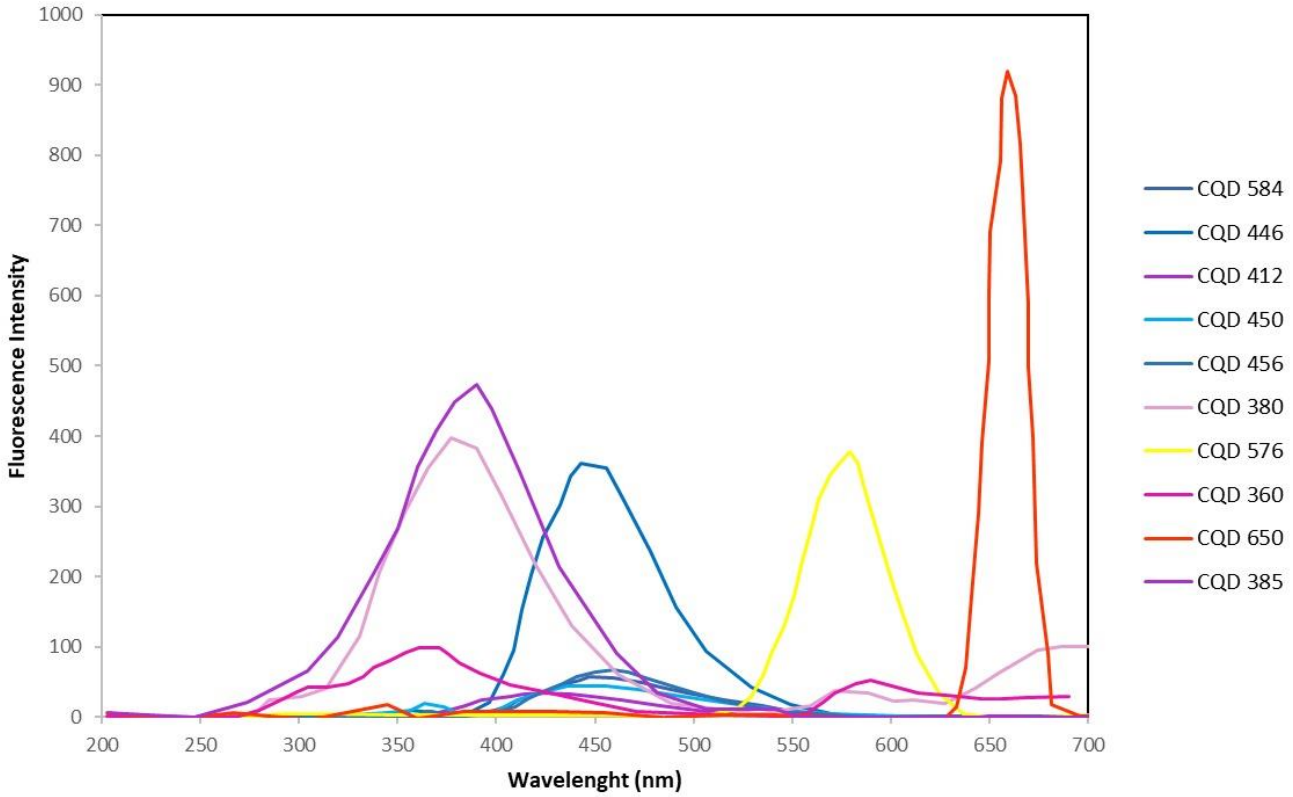
Multi tracer injection

Excitation	Emission	Color	Method	Solvent
266	454	Blue	Hydrothermal 1	DMF
388	446	Blue	Hydrothermal 1	W
327	412	Violet	Hydrothermal 1	W+Ethylenglicol
390	450	Blue	Electroquimica	W
386	456	Blue	Hydrothermal	Ethanol
270	380	Violet	Hydrothermal 2	W
272	576	Yellow	Hydrothermal 2	Acetone
250	360	Violet	Hydrothermal 2	W
350	650	Red	Hydrothermal 2	DMF
290	385	Violet	Hydrothermal 2	Ethyl Acetate
TOTAL	**10**	**4**	**2**	**5**

Succesful optimization towards to obtain different “colors”

Multi tracer injection



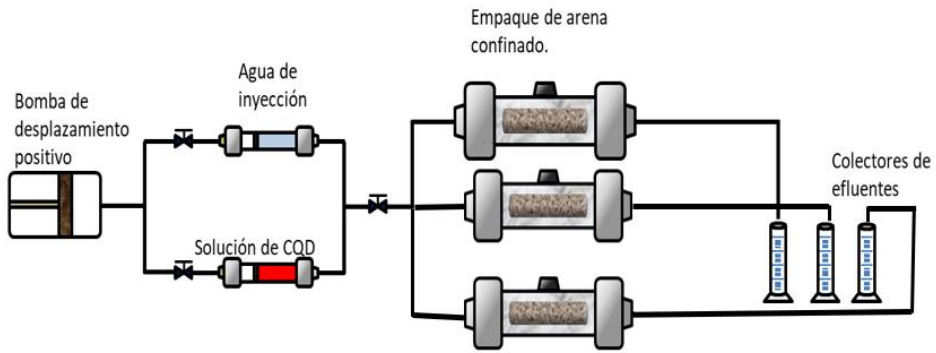
Succesful optimization towards to obtain different “colors”

Static and Dynamic retention

Static

Evaluation under conditions of interest (Stirring, Temperature, among others)

Dynamic



Dynamic evaluation under reservoir conditions

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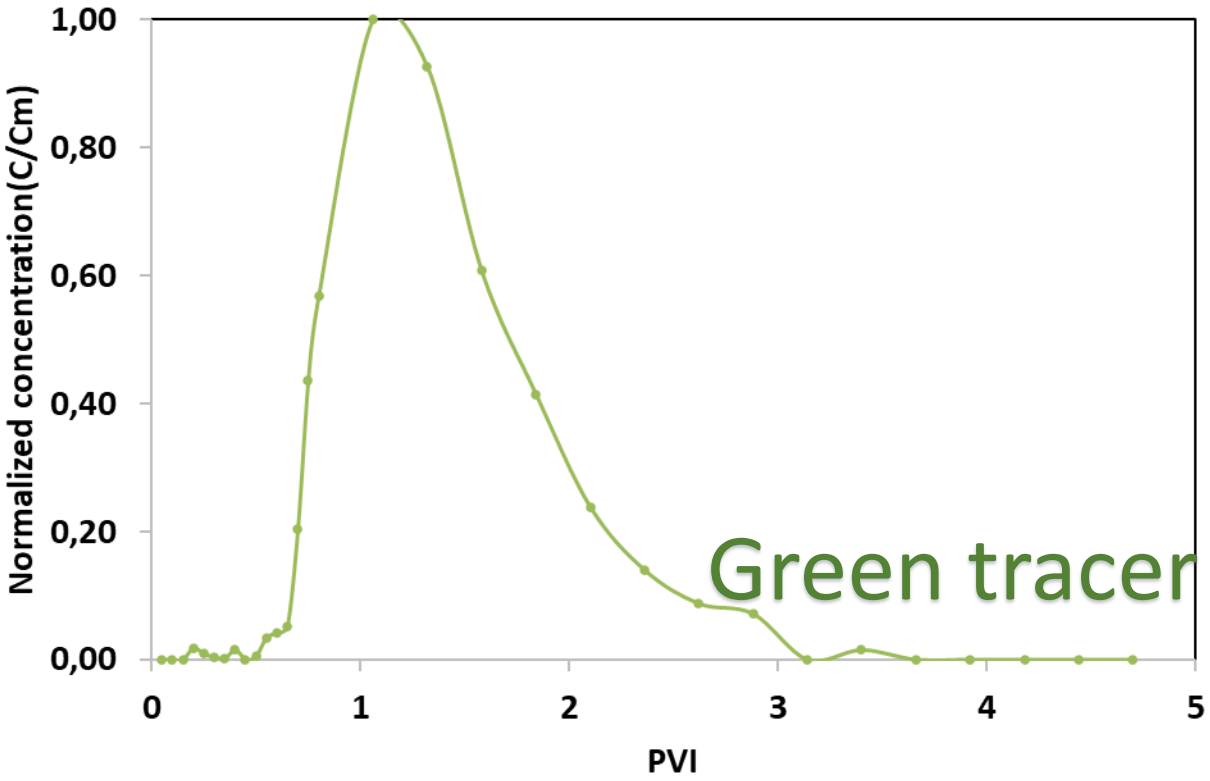
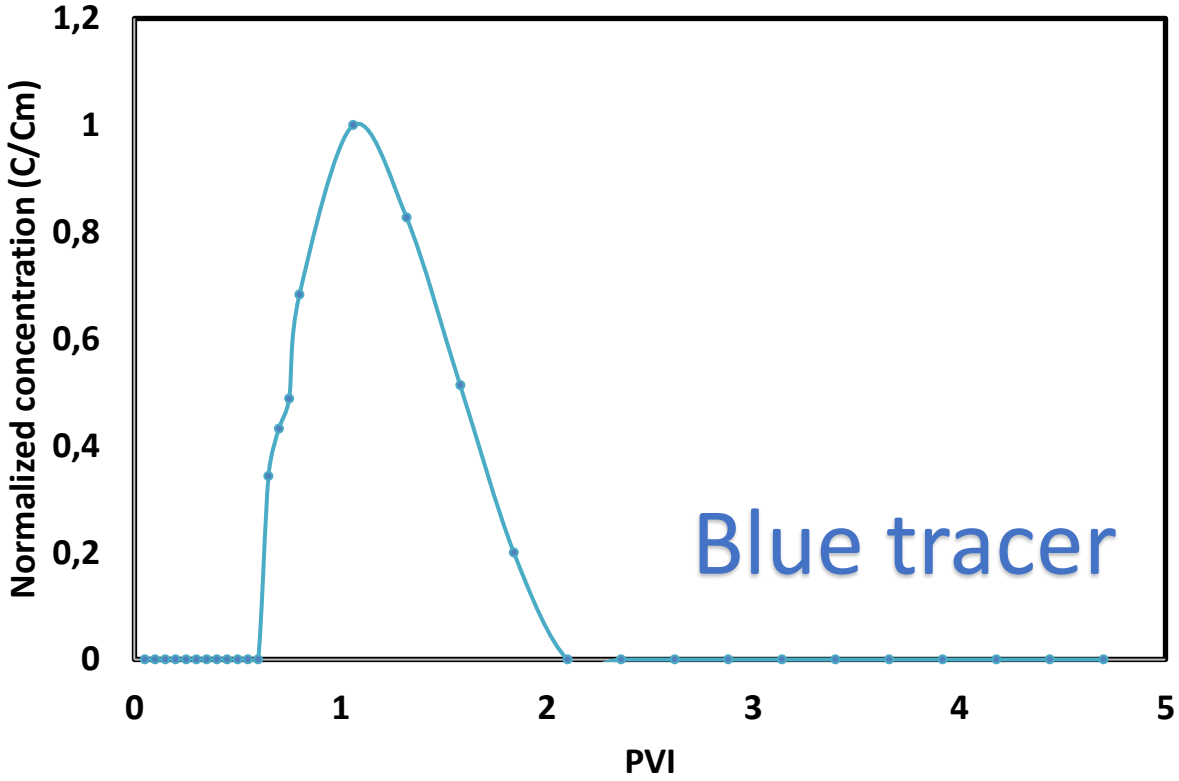
Static and Dynamic retention





Simultaneous quantification of each tracer

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Scheme injection for field trial

Injection Wells	Production Wells																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1			Blue CQD						Blue CQD				Blue CQD				Blue CQD	
2	Red CQD	Red CQD													Red CQD			
3	Green CQD		Green CQD															Green CQD
4									Green CQD							Green CQD	Green CQD	
5																		
6			Red CQD									Red CQD						
7		Green CQD																
8		Blue CQD																
9				Green CQD	Green CQD							Green CQD						
10					Red CQD	Red CQD	Red CQD							Red CQD				
11								Green CQD		Green CQD	Green CQD							

Information and knowledge about the field are of primary importance

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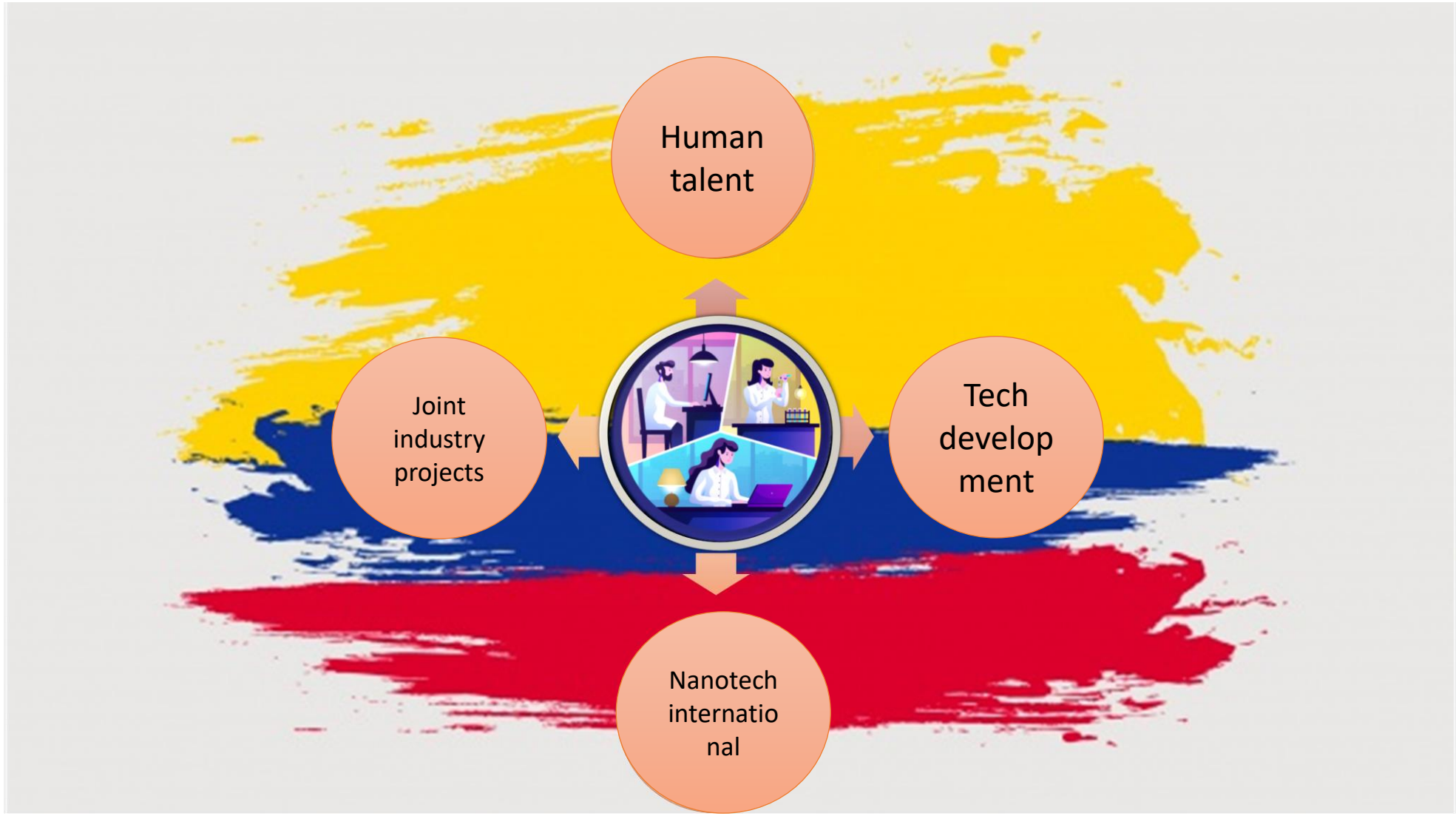
Human talent
Joint industry projects
Tech develop ment
Nanotech internatio nal

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