The radiation-induced synthesis of gold nanoparticles in ternary complexes of Au(III) with poly(1-vinyl-1,2,4-triazole) and poly(acrylic acid)

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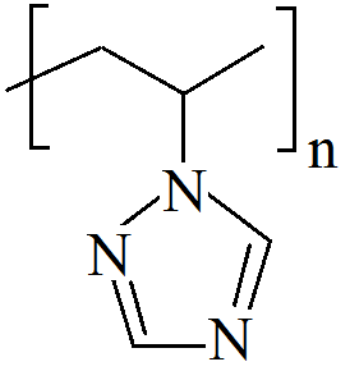
Introduction



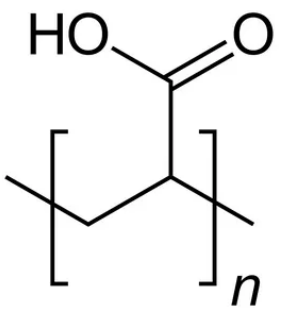
Poly(1-vinyl-1,2,4-triazole)

PVT as a stabilizing matrix for metal nanoparticles:

- Water soluble
- Non-toxic
- Biocompatible
- Chemical and thermally stable
- Triazole groups are an effective ligands for metal ions

AuNPs

Antibacterial materials
Biosensors
Catalysis
Drug delivery
Theranostics



Poly(acrylic acid)

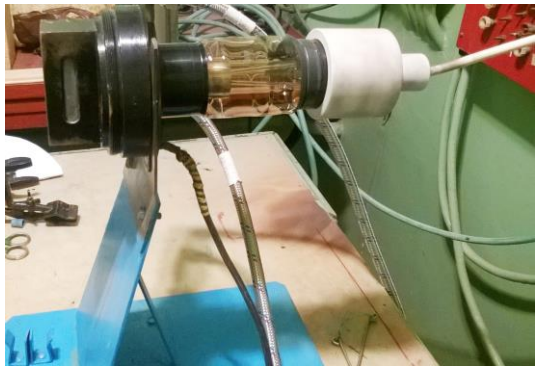
The Radiation-induced method for the preparation of metal nanoparticles

$$H_2O \rightarrow e_{aq}, {}^{\cdot}OH, {}^{\cdot}H, H_2O_2, H_3O^+$$

The radiation-chemical yields G_0 (X) (species/100 eV)
of products of water radiolysis at the homogeneous stage (~10^{-7} s)

e_{aq}	$\cdot OH$	$\cdot H$	H_2	H_2O_2
2,8	2,8	0,6	0,45	0,75

$E^0 (Ag^+/Ag^0) = -1.8$ V
$E^0 (2e^-_{(aq)}, 2H^+/H_2) = -2.9$ V
$E^0 (^{\cdot}OH/OH^-) = 1.9$ V
$E^0 (CH_3CHO, H^+/CH_3CH^{\cdot}OH) = -1.1$ V

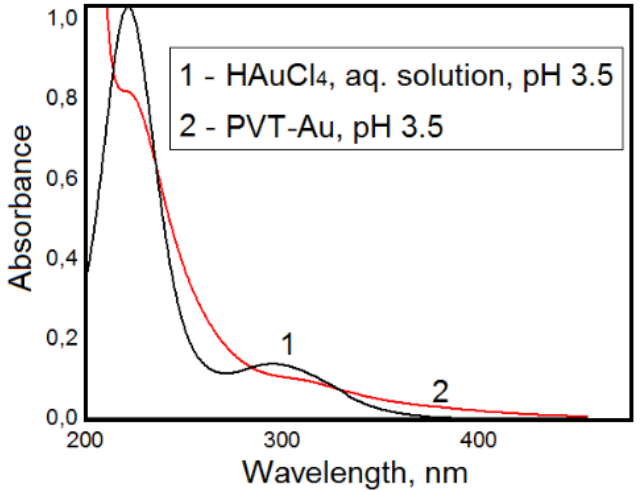


$$^{\cdot}OH + CH_3CH_2OH \rightarrow CH_3CH^{\cdot}OH + H_2O$$
$$^{\cdot}H + CH_3CH_2OH \rightarrow CH_3CH^{\cdot}OH + H_2$$

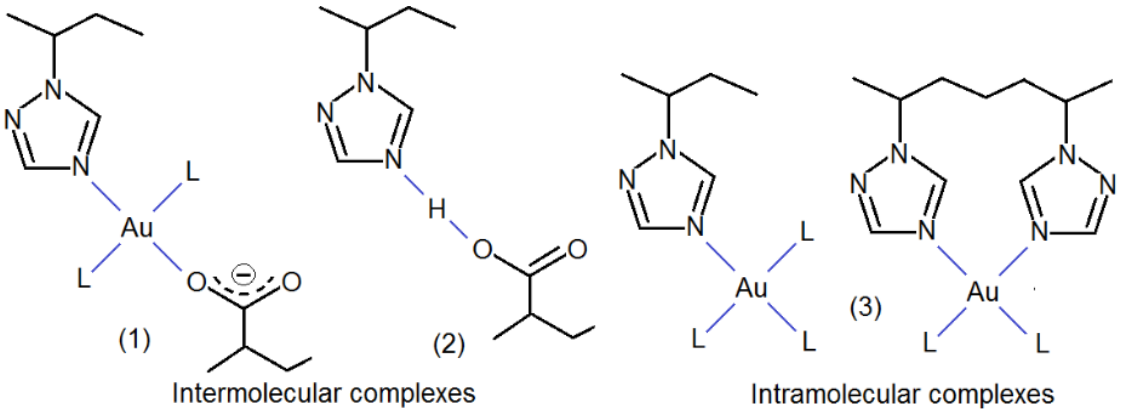
Advantages of the radiation-chemical method

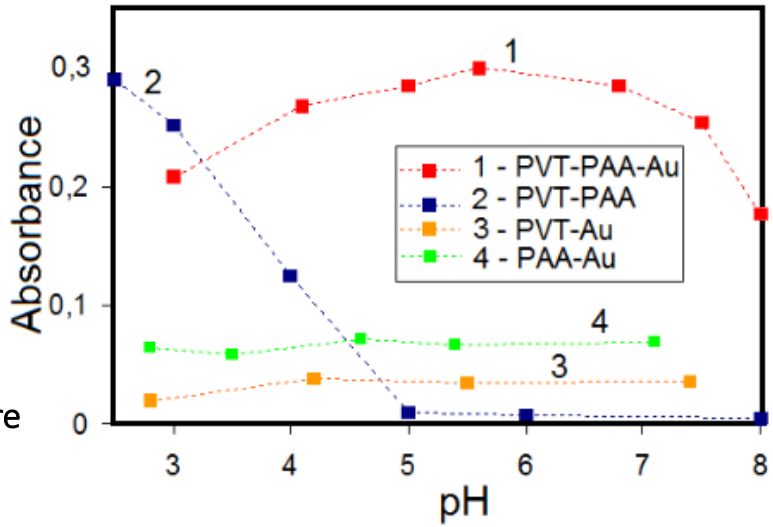
- Strong reducing agent
- No impurities of chemical agents
- The possibility to change the radiation parameters

The formation of interpolymer complexes PVT-PAA-Au(III)



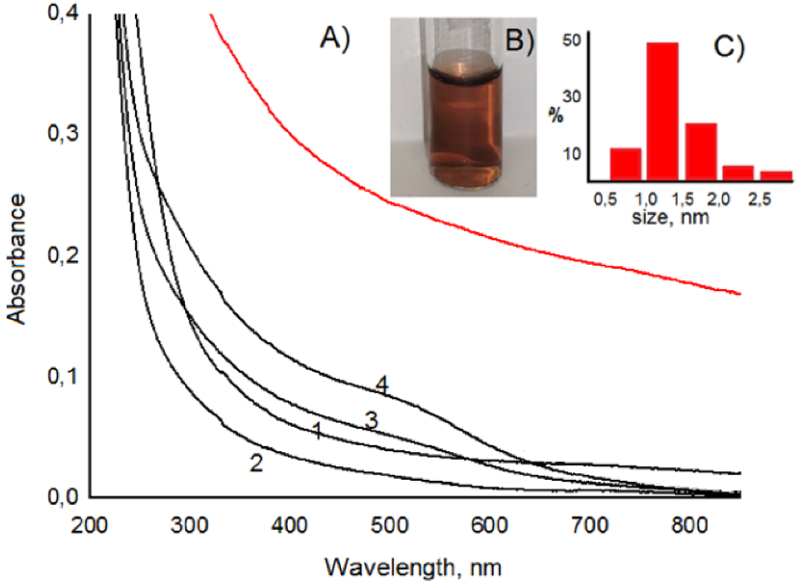
The UV-Vis spectra of $HAuCl_4$ and PVT-Au(III)



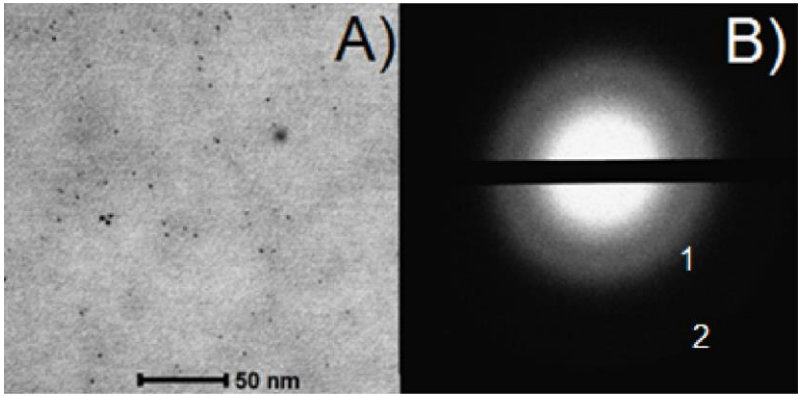


The turbidimetric data (the dependence of the optical density at λ = 400 nm on pH) of the unirradiated PVT-PAA-Au(III), PVT-Au(III), PAA-Au(III) suspensions and PVT-PAA aqueous mixture

The radiation-induced formation of AuNPs in the ternary complexes PVT-PAA-Au(III)



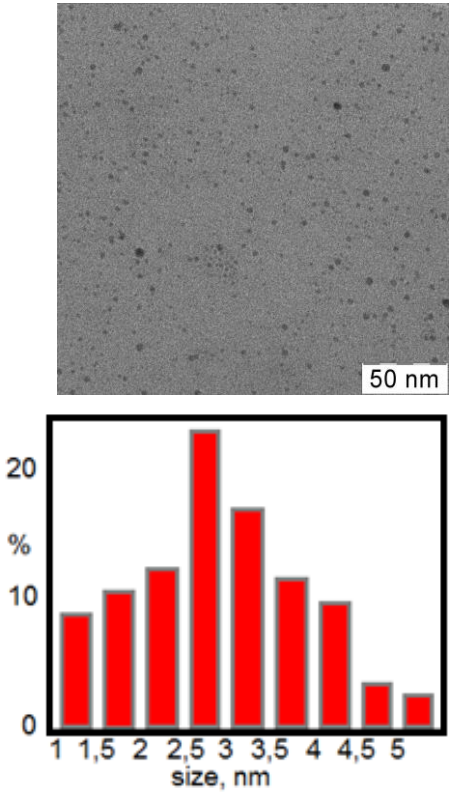
The UV-VIS spectra of PVT-PAA-Au suspensions irradiated up to a dose of 0 (red curve), 1.5 (1), 7 (2), 10 (3), 14 (4) kGy (A); the image of PVT-PAA-AuNPs colloids (B) and the size distribution of AuNPs (dose 14 kGy) (C)



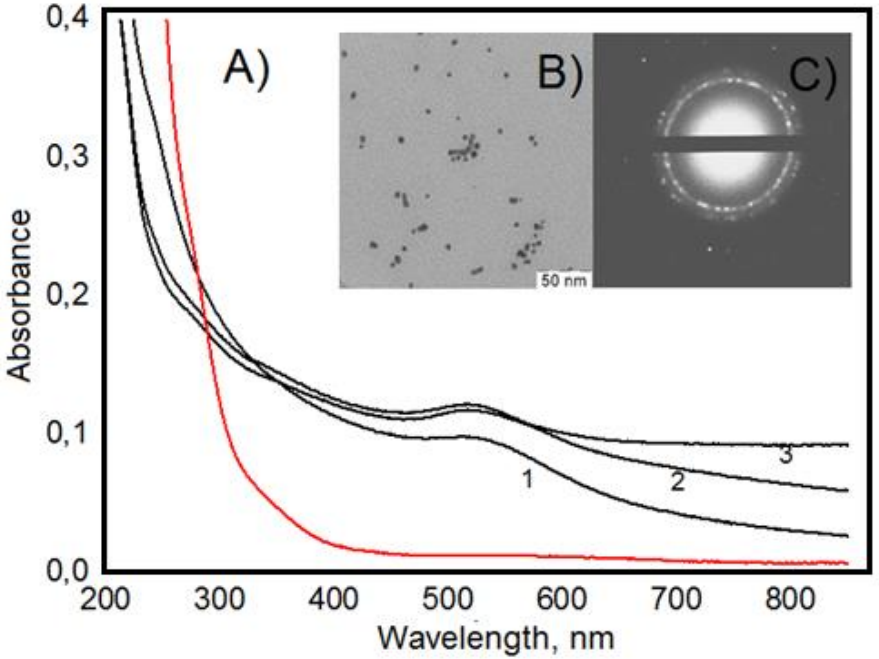
The TEM image (A) and microdiffractogram (B) of the irradiated (dose 14 kGy) PVT-PAA-Au suspension

	C(Au(III)), mol/l	*C*(PVT-units), mol/l	*C*(PAA-units), mol/l
PVT-PAA-Au	$6{,}4\cdot10^{-4}$	$7\cdot10^{-3}$	$9\cdot10^{-3}$

The radiation-induced formation of AuNPs in the double complexes PVT-Au(III) and PAA-Au(III)



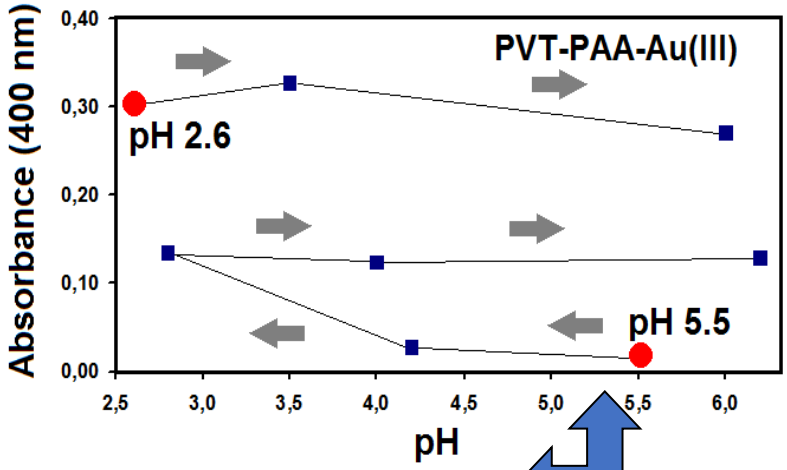
TEM image and the AuNPs size distribution of the irradiated (dose 14 kGy) PVT-Au solution

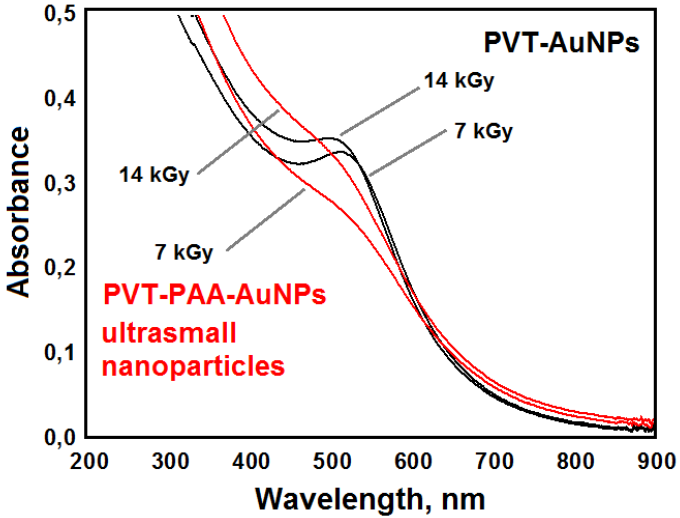


The UV-VIS spectra of PAA-Au suspensions irradiated up to a dose of 0 (red curve), 0.7 (1), 1.5 (2), 7 (3) kGy (A); The TEM image (B) and microdiffractogram (C) of the irradiated (dose 7 kGy) PAA-Au solution.

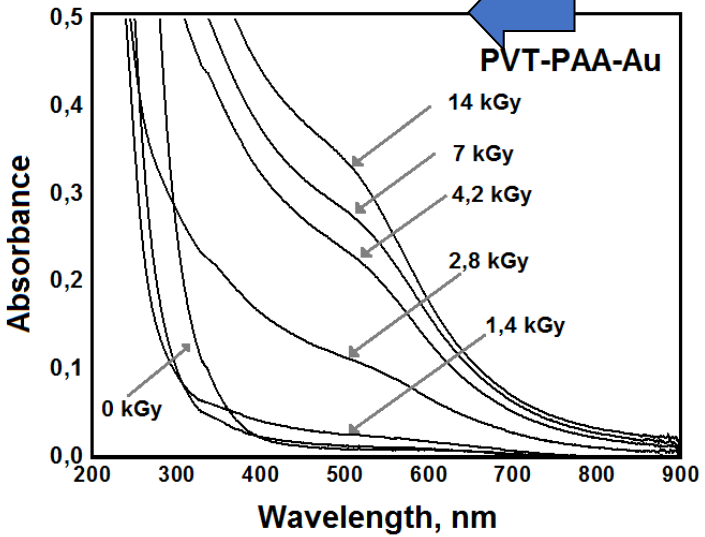
The radiation-induced formation of AuNPs in the ternary complexes PVT-PAA-Au(III)

The turbidity of the ternary PVT-PAA-Au(III) complex depends strongly on the way of its preparation

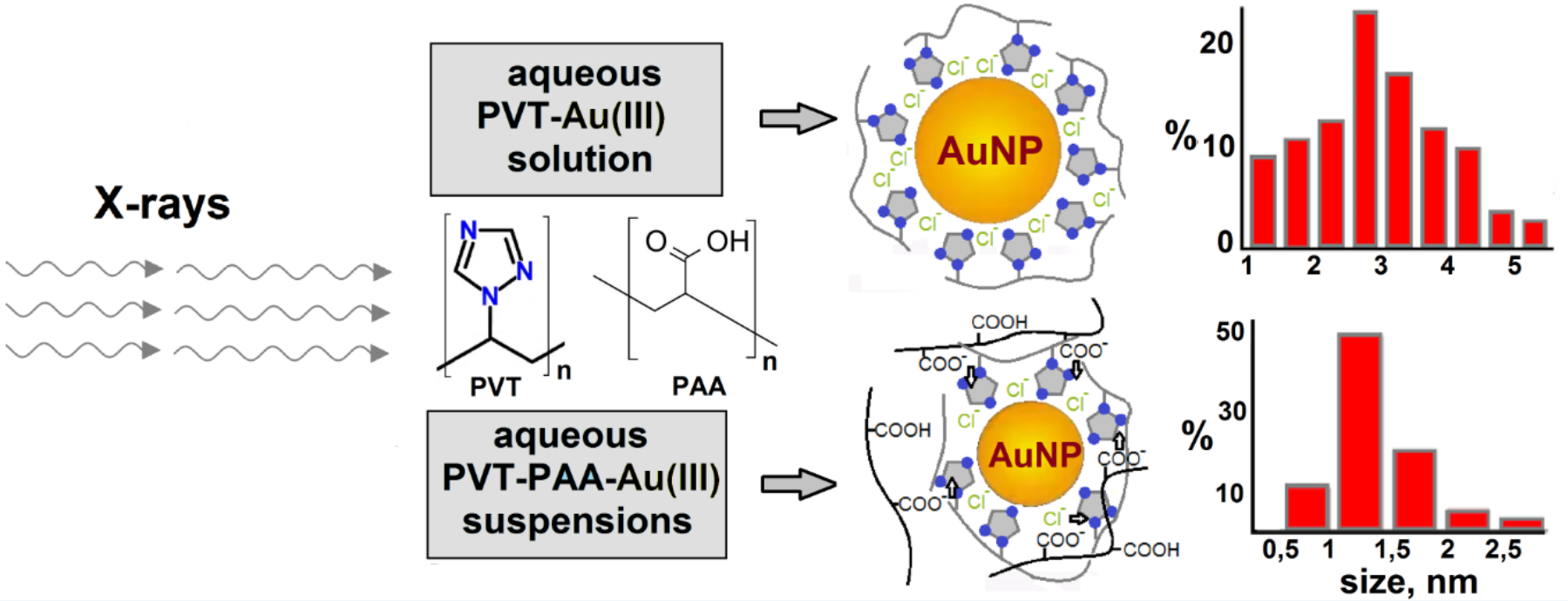




$C(\mathrm{Au(III)}) = 1.6*10^{-3}$ M



The radiation-induced formation of AuNPs in the ternary complexes PVT-PAA-Au(III)



Zharikov, R. Vinogradov, E. Zezina, A. Pozdnyakov, V. Feldman, A. Vasiliev, A. Zezin, The radiation-induced preparation of ultrasmall gold nanoparticles in Au(III) complexes with units of poly(1-vinyl-1,2,4-triazole) and poly(1-vinyl-1,2,4-triazole) – poly(acrylic acid), Colloid and Interface Science Communications, Vol. 47, 100602 (2022) https://doi.org/10.1016/j.colcom.2022.100602

Conclusions

- It has been found, that PVT, PAA and Au(III) yield ternary interpolymer complex PVT-PAA-Au(III), the structure of which depends on pH
- The metal–polymer nanocomposites PVT-PAA-AuNPs can be synthesized by the radiation-chemical method in solutions of PVT-PAA-Au(III) interpolymer complexes.
- The irradiation of the ternary PVT-PAA-Au(III) complexes makes it possible to synthesize ultrasmall AuNPs 1 – 1.5 nm in size.