SIMILARITIES ANALYSIS ON HYDROXYAPATITE-ZIRCONIA COMPOSITES

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OUTLINE

- ✓ Background
- ✓ Aim
- ✓ Material: hidroxyapatite-zirconia composite
- ✓ Method: Hierarchical Cluster Analysis
- ✓ Results
- ✓ Concluding remarks

BACKGROUND: HYDROXYAPATITE

- ✓ Importance:
  - implants materials
  - drug delivery systems

- ✓ Connection with Zirconia dioxide (ZrO_2)
  - Reinforcing phases due to its good toughness
  - Why? The properties of both materials are combined advantageously

AIM

- ✓ To analyze the similar characteristics of hydroxyapatite and three hydroxyapatite-zirconia powders with different phase composition, shape and grains size

MATERIAL: HYDROXYAPATITE AND HYDROXYAPATITE-ZIRCONIA COMPOSITES

- ✓ HIDROXYAPATITE: HAp
- ✓ HIDROXYAPATITE COARSE - GRAINED ZIRCONIA: HAp-CGZ
- ✓ HIDROXYAPATITE FINE - GRAINED ZIRCONIA: HAp-FGZ
- ✓ HIDROXYAPATITE NEEDLE - GRAINED ZIRCONIA: HAp-NGZ
- ✓ Sintering temperature: 1150°C, 1200°C, 1250°C & 1300°C

A. Rapacz-Kmita, A. Ślósarczyk and Z. Paszkiewicz: J. Eur. Ceram. Soc. Vol. 26 (2006) p. 1481-1488.

MATERIAL: HYDROXYAPATITE AND HYDROXYAPATITE-ZIRCONIA COMPOSITES

1. Vickers hardness = ability to resist to plastic deformation
2. Bending strength = upper limit of normal stress at which fracture or excessive deformation occurs
3. Characteristic strength and Weibull modulus = measurements of the degree of material reliability
4. Anisotropy = measurement of the speed of ultrasonic waves in directions perpendicular and parallel to the axes
5. Young modulus = physical property of being inflexible and hard to bend
6. Rigidity modulus = property of being stiff and resistant to bend
7. Poisson ratio = between strain of expansion in the direction of force and the strain of conc. perpendicular to the force

METHOD: HIERARCHICAL CLUSTER ANALYSIS

- ✓ Find relatively homogeneous clusters on cases based on measured characteristics
- ✓ Identify the relationship among entities by constructing a hierarchy or tree-look structure based on an ordering concept
- ✓ SPSS 12.0

RESULTS – PROXIMITY MATRIX

↑ characteristic strength, bending strength, anisotropy, inflexibility and hardness to bend & Vickers hardness

Composite	HAp_1	HAp_2	HAp_3	HAp_4	$HAp\text{-}CGZ_1$	$HAp\text{-}CGZ_2$	$HAp\text{-}CGZ_3$	$HAp\text{-}CGZ_4$	$HAp\text{-}FGZ_1$	$HAp\text{-}FGZ_2$	$HAp\text{-}FGZ_3$	$HAp\text{-}FGZ_4$	$HAp\text{-}NGZ_1$	$HAp\text{-}NGZ_2$	$HAp\text{-}NGZ_3$
HAp_1	0														
HAp_2	2513	0													
HAp_3	10363	2752	0												
HAp_4	23147	10495	2544	0											
$HAp\text{-}CGZ_1$	829	3528	12214	**25366**	0										
$HAp\text{-}CGZ_2$	3997	1672	5377	13505	3417	0									
$HAp\text{-}CGZ_3$	11889	4606	3487	6700	11002	2556	0								
$HAp\text{-}CGZ_4$	**24849**	12609	6683	4979	**23616**	10178	2540	0							
$HAp\text{-}FGZ_1$	656	3325	11888	24997	**25**	3449	11067	**23727**	0						
$HAp\text{-}FGZ_2$	4495	2216	6163	14397	3505	**67**	2515	10040	3582	0					
$HAp\text{-}FGZ_3$	10066	2576	415	3203	10778	4126	2063	5030	10591	4639	0				
$HAp\text{-}FGZ_4$	22594	10068	2713	422	23642	11974	4975	3016	23411	12581	2538	0			
$HAp\text{-}NGZ_1$	1528	4297	13325	26618	**120**	3523	10973	23450	**223**	3437	11491	**24487**	0		
$HAp\text{-}NGZ_2$	3636	1361	5221	13438	2539	944	3478	11033	2594	944	3575	11509	2540	0	
$HAp\text{-}NGZ_3$	10079	2577	322	3085	10911	4267	2211	5204	10696	4812	**17**	2519	11679	3747	0
$HAp\text{-}NGZ_4$	22690	10278	3433	1369	22786	11170	3948	1772	22676	11513	2638	297	23271	10499	2681

1250°C - ↓ Poisson ratio, Young modulus, rigidity, Weibull modulus anisotropy –↑ characteristic value

RESULTS – PROXIMITY MATRIX

The best alikeness:

- ✓ HAp-FGZ & HAp-NGZ (1250°C): ↓ Poisson ratio (0.004), Young's modulus (0.1 GPa), rigidity (0.2 GPa), Weibull modulus (0.3 MPa), anisotropy (0.37%) & ↑ characteristic value (4 MPa)

The worst alikeness:

- ✓ HAp (1300°C) & HAp-NGZ (1150°C): a value of absolute difference of 45 MPa is obtained for characteristic strength, of 44.7 MPa for bending strength, of 1.47 % for anisotropy, of 8.8 GPa for inflexibility and hardness to bend and of 1.4 GPa for Vickers hardness

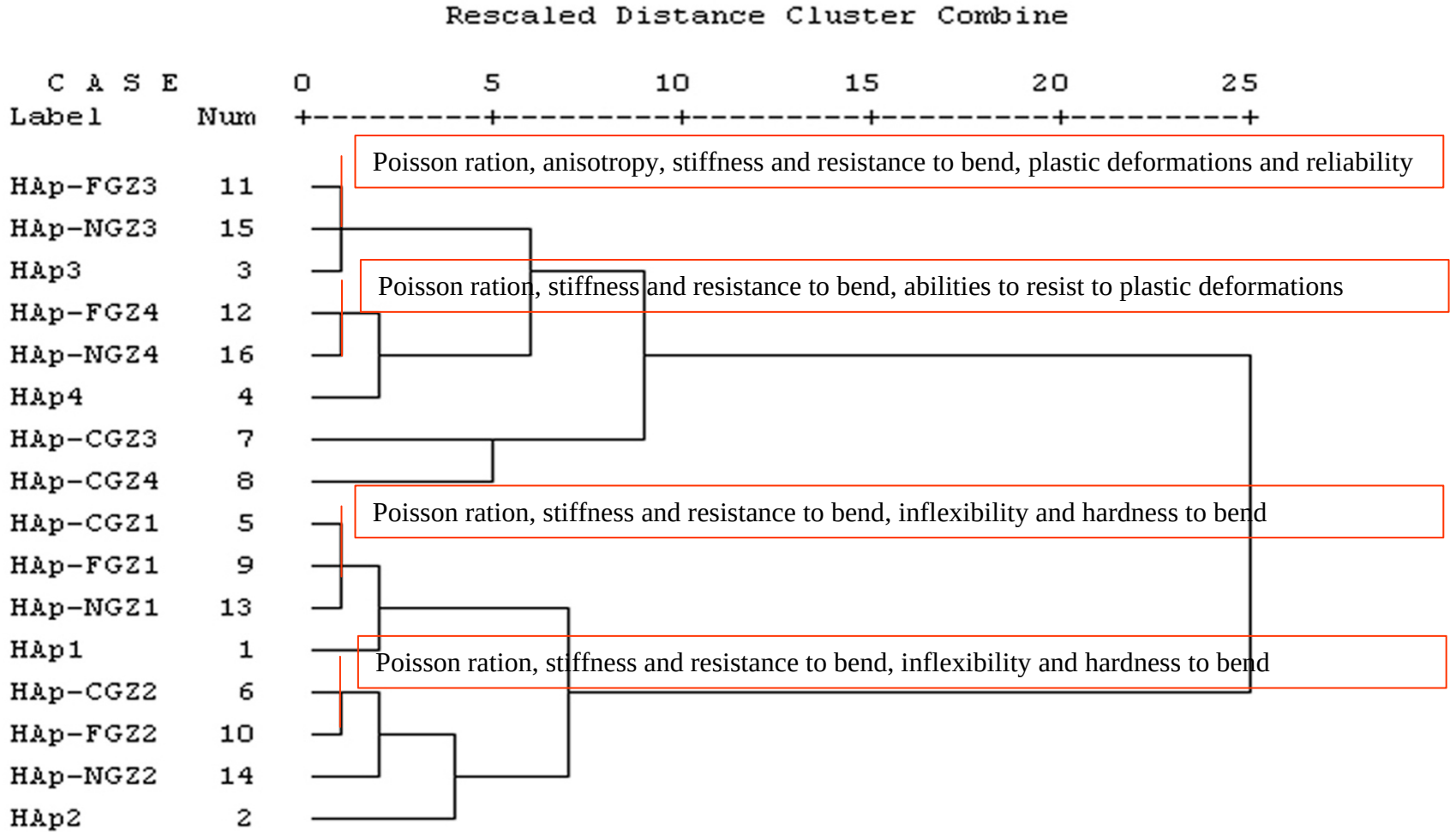
RESULTS – ICICLE PLOT

Cluster no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8:HAp-CGZ	X	X	X	X	X										
7:HAp-CGZ	X	X													
16:HAp-NGZ	X	X	X	X	X	X	X	X	X	X	X				
12:HAp-FGZ	X	X	X	X	X	X	X	X	X						
4:HAp	X	X	X	X											
15:HAp-NGZ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11:HAp-FGZ	X	X	X	X	X	X	X	X	X	X					
3:HAp	X														
14:HAp-NGZ	X	X	X	X	X	X	X	X							
10:HAp-FGZ	X	X	X	X	X	X	X	X	X	X	X	X	X		
6:HAp-CGZ	X	X	X	X	X	X									
2:HAp	X	X	X												
13:HAp-NGZ	X	X	X	X	X	X	X	X	X	X	X	X			
9:HAp-FGZ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
5:HAp-CGZ	X	X	X	X	X	X	X								
1:HAp	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

RESULTS – DENDOGRAM

* * * * * * H I E R A R C H I C A L C L U S T E R A N A L Y S I S * * * * * *

Dendrogram using Average Linkage (Between Groups)



CONCLUDING REMARKS

- ✓ Hierarchical cluster approach is useful in identification and characterization of similarities of studied hydroxyapatite and hydroxyapatite-zirconia composites.
- ✓ Sintering temperature is the most important variable used in clusterization, followed by Poisson ration. Other four parameters (out of nine) with importance in clusterization were Vickers hardness, anisotropy, Young's modulus and rigidity modulus.

ACKNOWLEDGMENT

The research was partly supported by UEFISCSU Romania through project ET108/2006.

Thank you for your attention!

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